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Contents

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Economical Addition to Cambridge, Mass., Supply

By Timothy W. Good

THE Cambridge Water Works Corporation was chartered in 1852 and came into possession of the City by purchase in 1865, when the name was changed to "Cambridge Water Works."

The original source of supply was Fresh Pond in Cambridge and Belmont (with a capacity of 1500 mil.gal.) which was enlarged by connection via conduit with Wellington Brook and Spy Pond, Arlington. The waters of these additional sources were adjudged unfit for domestic use in 1880 and since that time have not been utilized for a supply in Cambridge.

In 1887, Fresh Pond was augmented by a storage reservoir constructed on Stony Brook, located in Weston and Waltham which provided for an additional 402 mil.gal. of storage.

In 1897, an additional provision was made for storing of water in two large reservoirs artificially formed by constructing two dams across Hobbs Brook, a tributary of Stony Brook, flowing through Lexington and Lincoln, with a capacity of 2710 mil.gal. Payson Park Distributing Reservoir was also completed in 1897, with a storage capacity of 43 mil.gal.

Water flows through an open brook from Hobbs Brook to Stony Brook; from Stony Brook to River Street, Waltham, through 36-in. and 30-in. cast iron pipe; from River Street, Waltham, to the purification works through a 63-in. concrete conduit.

All of these improvements were results of recommendations made by the following engineers: Frederick P. Stearns, Allen Hazen and Chester M. Everett. From reports submitted by them, Cambridge was assured of a continuous supply of 13 mgd.

The average consumption up to 1940 was approximately 12 mgd. In 1941, the average consumption was 13.75 mgd. This increase was due to the fact that over seventy industries in Cambridge are engaged in war production work on a three-shift basis.

A paper presented at the Superintendents' Prize Contest Session on June 17, 1943, at the Cleveland Conference by Timothy W. Good, Gen. Supt., Water Dept., Cambridge, Mass. This paper was tied for first place in the Contest.

Lack of precipitation, the extremely dry periods of 1941 and 1942, and the possibility of additional consumption made it necessary for the Water Board to consider the best method of increasing our supply, either by taking ground water from wells in the vicinity of Fresh Pond or by joining the Metropolitan Water System.

Work of Geologist

Test wells were driven in the area surrounding Fresh Pond, and the concern engaged in this work offered to furnish bond and guarantee 5 to 6 mgd. for at least twenty years. Permission was obtained from the Department of Public Health to use this water provided that it was pumped into Fresh Pond and passed through the purification works. Before proceeding with the work, however, the Water Board engaged the services of Irving B. Crosby, Geologist, who reported that the water pumped in from the location on Concord Avenue would be drawn from the underground stream supplying Fresh Pond, and that better results could be obtained by lowering the level of Fresh Pond to Grade 10, where an inexhaustible supply of from 5 to 6 mgd. would always be obtained due to the glacial formation underneath a particular section of Fresh Pond. He pointed out that this water would come up through a natural gravel formation, surrounding clay and rock, found near the Huron Avenue and Concord Avenue sections of Fresh Pond. Mr. Crosby's recommendations were adopted, and we immediately closed down the 30-inch gate at Stony Brook and started pumping our additional requirements from Fresh Pond. Since 1941 we have been drawing 12 mgd. from Stony Brook, and 3½ to 5 mgd. from Fresh Pond, and, notwithstanding this fact, the Pond was 4 ft. higher on March 31, 1943, than on January 1, 1941. In the opinion of the Water Board and our experts, this is a permanent addition of 5 mgd., the only cost of which was $450 paid to Mr. Crosby for his services.

Originally, water flowed by gravity from Fresh Pond to the pumping station, but on the advice of Messrs. Hazen and Everett, the intake in the Pond was lowered 30 ft. in 1932, and it was due to the foresight of these engineers that we are now able to follow Mr. Crosby's recommendations.

The quantity of water delivered to the filters for the first four months of 1943 amounted to 15.45 mgd. Our pumpage for the first four months of 1943 was 14.45 mgd. The water used for washing filters accounts for the difference between the amount delivered to the purification works and that pumped through mains.

It may be noted that, when the purification works were originally put into operation, all wash water passed into the sewer, but in 1939, on the advice of our engineers, this water was rerouted and passed into a remote section of Fresh Pond for storage purposes, with a saving of 1 mgd.

Interest of Metropolitan System

The Metropolitan Water System has been seeking to have not only Cambridge but all cities and towns within a 10-mile area of the State House join the Metropolitan System. The original entrance fee for Cambridge of $4,000,000 was later reduced to $2,000,000, and since the construction of the Quabbin Reservoir has been reduced to approximately $200,000. The Water Board has refused to join the system, and in making its decision has taken into consideration the reports of emi-

nent engineers: Frederick P. Stearns in 1911 (who constructed the original Metropolitan Water System), Prof. Hector J. Hughes in 1912, and Hazen and Everett in 1931. In addition to the entrance fee, there would be a charge of between $70 and $75 per mil.gal. for *raw* water delivered to the distribution system. The principal objection was due to the fact in the last days of the closing session of the Massachusetts Legislature in 1941, a new law was adopted which provided that cities and towns joining the Metropolitan System *must* relinquish their present method of supplying water. The Cambridge Water Department delivers filtered water to the distribution system at a cost of $30 to $32 per mil.gal. This charge includes the total expenses incurred in operating the pumping station, purification works and all reservoirs. Surrounding cities and towns, members of the Metropolitan System, have charges as follows for unfiltered water:

Arlington	$ .23	per 100 cu.ft.
Belmont	.333	" " "
Boston	.184	" " "
Everett	.15	" " "
Lexington	.30	" " "
Malden	.19	" " "
Medford	.20	" " "
Melrose	.20	" " "
Newton	.18	" " "

If Cambridge entered the System, it would mean an increase in our rates over the present charge of 10 cents per 100 cu.ft. for purified water. All consumers and manufacturers are high in their praise of the quality of our water, and there is a strong objection on the part of all our citizens to relinquish the present method of serving purified water at a low cost.

There was also included in the law enacted by the Massachusetts Legislature in 1941 a provision that the Department of Public Health "shall report to the Metropolitan District Commission each of said towns which it finds cannot be so supplied continuously with a quantity ten per cent in excess of its average consumption during the three previous calendar years, and shall notify each of said towns of its findings with respect thereto."

Insurance Charge Assessment

It appears that the Department of Public Health certified to the information that we had a safe yield of "only about 8 per cent in excess of the average daily water consumption for the years 1939, 1940 and 1941." In making the recommendation to the Metropolitan District Commission, they did not consider the fact we had a surplus of from 4 to 5 mgd. available at Fresh Pond (together with a saving of 1 mgd. on wash water), and arbitrarily assessed the City of Cambridge an insurance charge of $55,857.68 for the year 1942 and again placed the charge for the same amount against the City for 1943. As a matter of fact, we have pumped from 16 to 19 mgd. over a long period, and for one week had a consumption of at least 20 mgd. since Mr. Crosby's recommendations were adopted. We have protested this charge by the Metropolitan District Commission on the ground that instead of a deficit we have a surplus of water. For instance, the Hobbs Brook Reservoir, with a capacity of 2710 mil.gal., has been closed since November 18, 1942, and the 14 to 16 mgd. that we are supplying the City has all passed through the Stony Brook and Fresh Pond systems.

Our system has a valuation of over $9,000,000 with an outstanding debt of but $428,500. The City Manager, the Mayor of Cambridge and the City

Council feel it would be unwise to abandon it unless the State recompenses the City of Cambridge in a manner similar to the arrangements made with Boston and other cities when they originally joined the Metropolitan District Commission. As the area of Cambridge is less than six square miles, with two miles of streets, parks, playgrounds, etc., it is their opinion that by using our present methods Cambridge has sufficient water to supply our needs for many years to come. Whereas engineers estimated the population for 1925 would be 125,000, with an estimated increase of 1200 each year, or 146,000 in 1943, the last census in 1940 shows a population of 110,800.

It may be added that 10 per cent of the water pumped is used on City enterprises—schools, hospitals, municipal buildings, parks, playgrounds and fire protection. No charge is made for same, while the Water Departments in many cities and towns receive a credit for water furnished to other municipal departments.

It might be interesting to note the average charges for water during the years 1941 and 1942 amounted to approximately \$550,600. This water is supplied through 15,000 meters, one-third of our receipts each year being paid for by fourteen large water users.

We have cut down our automotive equipment capacity 35 per cent in order to save gasoline, tires, etc.

In an effort to conserve water, the hours have been reduced for use of hose on lawns, parks, playgrounds, swimming pools, golf course, etc., and we have had 100 per cent co-operation from the water users of Cambridge.

Inasmuch as the War Department has considered the buildings of the Cambridge Water Department in a vulnerable area, steel fences with barbed wire tops have been erected, completely enclosing the pumping station and purification works; gates are kept locked and no one is allowed to enter premises without a permit from the Superintendent of the Water Department. Twenty-four hour police service is maintained on all buildings and reservoirs, and we have the co-operation of the police of the City of Waltham, Town of Belmont, Town of Lincoln and Town of Weston, where our reservoirs are located.

During these trying times the morale of the Water Department has been excellent. All employees are imbued with the spirit that we *must and will win the war,* and they feel that their work is just as important as other work in different lines. It has made no difference whether their services were required night or day, Sunday or holiday, or whether the outside temperature was 100° in the shade or 15° below zero. All have responded without hesitancy, feeling that only in this manner are we going to bring this war to a successful conclusion.

Kansas City Improvements Meet Wartime Conditions

By Kenneth K. King

SINCE the Spring of 1940, many changes have been effected in the Kansas City, Mo., Water Department, some in the form of additional or improved services to the consumers of water, and others to effect economies and make possible improvements not otherwise obtainable without increase in water rates. All of the economies and improvements have aided greatly in meeting wartime emergency conditions. Up to the present time, the only improvement adding materially to operating costs has been the softening of the water, but the costs of operation are still far below those of years previous to 1940.

Before describing some of the changes that have been made, a brief description of the size and general scheme of the Kansas City water system may be of interest to those not acquainted with it.

The system serves a population now estimated at 525,000 persons, approximately one-fifth of whom are in suburban and rural areas and buy through master meters at the city limits. The area served is 302 sq.mi., of which 242 sq.mi. are outside the city limits. Water pumped averages about 57 mgd., with a maximum to date of 96 mgd.

The supply is taken from the Missouri River, the river intake and treatment works being east of the river and about four miles north of the City. An adequate description of the treatment works would require several pages. A complete description of the purification and softening processes has been published by M. P. Hatcher who is Chief Engineer of the Department (Jour. A.W.W.A., **34**: 703 (1942)).

Before the facilities for softening were completed in 1942, the plant had a nominal capacity, limited by the filters, of about 100 mgd. Since softening, the limitation is principally in the discharge header for the secondary low head electric-driven pumps, which have a rated capacity of 125 mgd. Comparatively minor modifications would increase the capacity of the works to 150 mgd.

The improvements in the treatment works in 1942, costing $900,000 of funds obtained from revenues after reduction in operating costs, were principally a new chemical storage and handling building necessary for the greatly increased quantities of chemicals used, the changing of mixing basins, and the addition of mechanical equipment to existing settling basins. The expenditure for softening facilities would be justified by increased plant capacity,

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even if the benefits of softening were not obtained, since the greater capacity soon will be needed due to the expanding war industries and population growth.

Refunding Bond Issue

One of the problems inherited by the new administration in the Spring of 1940 was the obvious necessity of refunding an $11,000,000 bond issue sold in 1922, on which nearly $9,000,000 has been paid in interest, but for which no sinking fund was available to retire the debt when due July 1, 1942. The bonds were sold chiefly to obtain funds to build the treatment works at North Kansas City, the East Bottoms High Lift Station and certain pressure tunnels and large mains. A sinking fund had originally been established and had reached $2,306,843.41 by 1930, but these funds were diverted to other uses to such an extent that on March 31, 1940 only $43,603.91 remained. It no doubt was fortunate that about two years remained before this debt had to be met. After more than a year of improved operation of the Department, the bonds were refunded with serial bonds, partly general obligation and partly revenue bonds, at low interest rates, so that the entire $11,000,000 will be paid in installments to be completed in 1961.

The plant investment of the Department is $28,146,754.50, and the bonded debt is $13,652,000, requiring the heavy annual principal and interest payment of about $886,000 until the $11,000,000 issue is retired.

Savings in Operating Expenses

The tabulation below will illustrate the extent of savings in operating expenses that are being made. For comparative purposes, the term "Operating Expense" includes all expenditures exclusive of those for debt service and capital outlays. The amounts available for debt service and capital outlays are included under "Net After Operation." Figures shown for periods prior to 1940 are based on the Department's annual reports, although later auditing made minor changes for the year 1939-40.

Operating expenses in the past three years have been lower than in any year since that ending April 30, 1918, when the population served was estimated at 300,000 persons, the revenue was $1,306,233 and the expense $892,481. Operating expenses rose to $1,566,892 by 1920–21. Salaries and wage rates paid now are more than 50 per cent

Tabulation Showing Savings in Operating Expenses

	Revenue	*Operating Expense*	*Net After Operation*
Avg. of 19 years to April 30, 1939	$2,122,640	$1,438,367	$ 684,273
Avg. of 10 years to April 30, 1939	2,261,871	1,483,620	778,251
Avg. of 5 years to April 30, 1939 *	2,295,189	1,523,591	771,598
Year ending April 30, 1939 (Maximum expense recorded)	2,248,089	1,616,652	631,437
Year ending April 30, 1940	2,350,979	1,358,155	992,824
Year ending April 30, 1941	2,351,102	1,042,832	1,308,270
Year ending April 30, 1942	2,293,483	1,015,019	1,278,464
Year ending April 30, 1943	2,355,402	1,115,438	1,239,964

* In addition to the expense shown, "back-pay" suits in excess of $1,000,000 have been brought against the City by Water Department employees of the period ending April 30, 1939.

above those of 1917–18, and have been increased an average of 22.7 per cent since April 30, 1940.

The expense shown for 1942–43 includes $95,413 for additional expense of water softening after August 1, 1942 and $70,196 for armed guards necessitated by the war. Without these two items, the operating expense for the past year would be only about $949,829.

The average ratio of operating expense to revenue for the past three years is 45.3 per cent. The average for the 20 years preceding is 67.2 per cent.

The saving in operating expense has been accomplished largely by reduction in number and improvement in efficiency of personnel employed, with less but material economies effected through better purchasing practices. The Department now employs about 375 persons, exclusive of armed guards performing no service except the important but abnormal one of guarding the properties. There are fewer employees than at any time in the past 25 years, the peak having been in 1938–39 when there were approximately 900. On April 30, 1940 there were 630 employees, this number having remained practically constant through the preceding year. By the reduction in number of employees during the past three years, the Department has released 255 persons who are thus made available for the armed forces or for war production.

Purchasing practices now assure honest competitive bidding with equal opportunities for all suppliers. Requirements are well advertised, and awards made entirely on the basis of the best prices for the quality specified.

The contract for electric power was re-negotiated, saving $30,000 per year. Demands at the electric pumping stations have been reduced by close control of load peaks, with consequent savings in addition to the $30,000, this also assisting the power plant in meeting increased wartime demands.

The use of motor vehicles for other than department business has been stopped, and their use has been greatly reduced even for legitimate purposes. Careful cost records are kept for each item of motor equipment, based on daily reports of mileage, on gasoline consumption, and maintenance and repair costs. Each operator is held responsible for performing his duties with the least possible mileage, routing being carefully studied and planned in advance where possible. Considerably less than one-half as much gasoline is now used than was used in the year ending April 30, 1939. The saving in tires is proportional.

Meter Checking Program

Periodic checking of water meters was introduced, and charging for repairs of smaller sizes of city-owned meters discontinued, with householders permitted to transfer ownership to the City, so that meters could be exchanged and one trip made instead of the two required when the same meter had to be returned. The periodic checking, cleaning and repair make possible the reconditioning and use of meters and parts that might otherwise have to be replaced with new, with consequent consumption of greater quantities of critical materials. This program, together with economy efforts of street and boulevard cleaning divisions of other departments using water for flushing, has reduced the unaccounted for water and "free" water from about 33 per cent to about 26.5 per cent.

Changes in methods of water purification have reduced the amount of alum used by 2000 tons per year, giving

FIG. 1. Bookkeeping Machines and Visible Index Posting Trays for Inventory Control

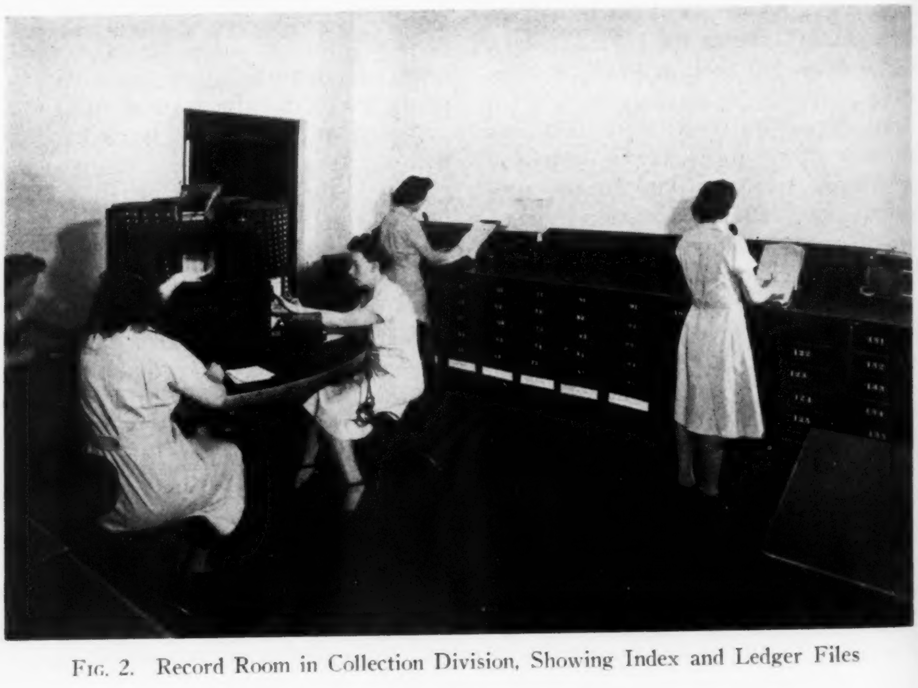

FIG. 2. Record Room in Collection Division, Showing Index and Ledger Files

an estimated saving in bauxite of 630 tons. Greater amounts of iron sulfate, soda ash and lime are used; but the saving in the critical bauxite is enough to produce approximately 150 tons of aluminum, now so essential in the war effort.

In 1941, with the aid of outside consultants, new systems were installed in the Administration and Collection divisions, for cost accounting, stores inventory, payroll distribution, transportation cost distribution, consumers' accounts, and all the routine office work of these divisions.

Cost accounts are kept in accordance with the *Manual of Water Works Accounting* (distributed by the A.W.W.A. as a co-publisher), using a most modern machine bookkeeping system. Stores inventory records are kept using the same machines and visible index posting trays. The payroll labor distribution, and the transportation cost distribution for about 116 pieces of transportation and other equipment, require the time of two clerks and part of the time of one calculating machine operator. Some unusual and convenient forms are used, as were illustrated in Special Bulletin H, April 1943, published by the Municipal Finance Officers Association.

New Collection Accounting System

In the Collection Division, the system was almost entirely changed. New ledgers were made, using a double entry system instead of the former single entry, so that partial payments may be accepted and necessary charges carried to the next billing. The billing machines also had to be changed to permit adding to subsequent bills. Previously, it was exceedingly annoying to all parties concerned that there was no means of recording acceptance of other than the full payment of water bills, it being necessary to return checks lacking only a few cents of a penalty charge for late payment. In opening new accounts, closing accounts, and furnishing duplicate bills, clerks maintain telephone contact with the record room, where are located the ledgers and a Flexoline file cross-referencing every account both by name and address. Any of the services described is accomplished in not more than 4 minutes, usually less. Deposits may be transferred from one address to another on written, telephoned or personal instructions; and current accounts receivable also are transferred, making it unnecessary to render a final bill, this constituting appreciated improvements not formerly permitted. The former practice has been discontinued, that requiring new consumers to pay the overdue accounts of previous residents of premises before they would be given water service. A complete re-routing of meter readers, done entirely by employees of the division, has very greatly reduced meter reading time required. Cycle billing was begun in the last few months of the previous administration, leveling off the load and permitting reduction in personnel required. Post card machine billing is used, all data on the cards being printed on machines in the office. The cards are first addressed and printed using a machine purchased in 1941, and then completed on the billing machines. There are about 87,500 accounts, of which about 81,400 are billed bi-monthly, 3500 larger accounts are billed monthly, and 2600 flat rate accounts billed quarterly in advance. While the installation of the new systems has resulted in large cost reductions, the new systems have meant a greater improvement in service, and

complaints have been reduced correspondingly.

The principal operating division of the department is that of Engineering, employing about 275 persons. It is responsible for purification, pumping, distribution, engineering planning, maintenance, and construction activities. Several projects for improvement of the system have had to be deferred on account of the war. Plans have been completed for a central garage and storage building, estimated before the war to cost $300,000 and for which a 4½-acre tract in a favorable location has been acquired at a cost of $50,000. Some of the specific savings due to the efficient operation of this division have been enumerated, and the others are reflected in the reduced operating expenses of the department.

Kansas City has a Mayor-Council-City Manager form of government, the city manager being appointed by the elected mayor and council. The city manager appoints the directors of departments. The improvements in the Kansas City Water Department have been made possible by unusually able elected officials who have supported a merit system for employees and a business administration through an experienced and trained professional city manager, and the improvements have been accomplished through the co-operation of all of these officials and the efforts and loyalty of the Water Department employees of all ranks.

Water Saving Survey in Allentown, Pa.

By William R. Schnabel

MANY water works in the United States have conducted leak surveys to ascertain the tightness of their distribution systems and the condition of the valves and of the services leading therefrom. No doubt hundreds of other water works, which have been serving water for many years, are greatly in need of such a survey.

If a system is fully metered, checks of master meters against totals of all meters on the distribution system can be employed as a basis for a close approximation of leakage; but on a system that sells water almost wholly on a flat rate, no such check can be made. It is then imperative that a measurement of flow in all pipes be made.

The city of Allentown, Pa., with a population of 100,000, found itself confronted, during the last several years, with a sharply increased demand for water, which reached a peak in 1941 due to adjustment of new plants to the war and a resultant growth in population. At the same time priority ratings limited the city's ability to enlarge its filtered water capacity.

Total plant capacity is 22 mgd., of which a little more than half is secured from two large springs, the balance being pumped and filtered from the Little Lehigh Creek. One of the springs has a normal flow of approximately 9 to 12 mgd., the water of which is conveyed through 5 mi. of 30-in. cast-iron pipe to the main pumping station, adjacent to the filter plant, both of which are located within the city limits.

The water works, which is municipally owned, was originally operated by a private company, beginning in 1820. The system was purchased by the city in 1869 and from that time until 1927 the entire supply was obtained from the two springs. In 1927, the city built a modern 10-mgd. filter plant to open the way for additions to the spring supply. When the filter plant was built, consumption averaged 13.7 mgd., increasing yearly until it reached a maximum of 18.93 mgd. in 1941.

As the two spring supplies are dependent to a great degree on the rainfall, flow varies from year to year. In 1941, the total rainfall was but 28.2 in. compared with a normal average of 42.0 in. This deficiency lowered the flow of springs and, during this dry

A paper presented in the Superintendents' Prize Contest on June 17, 1943, at the Cleveland Conference by William R. Schnabel, Supt. & Engr., Bureau of Water, Allentown, Pa. This paper was awarded Third Prize.

summer, the filter plant operated at above rated capacity.

Most of the water is sold on a flat rate, only 320 meters being used, these chiefly on services to large industrial and commercial establishments. The total number of services is 24,150, including those metered.

Considering the fact that all of the water is pumped against a head of 280 ft., the rates, both flat and meter-schedule, average as low as any in the country.

There are two large covered concrete distribution reservoirs, built in 1936–38, of 10- and 30-mil.gal. capacity, respectively.

The system includes 170 mi. of cast-iron mains in sizes from 4 to 36 in. in diameter, some of which are a hundred years old. All of the services are of lead pipe and many are as old as the water mains.

In the distribution system, there are 3513 street valves, all opening to the right, of which 763 are control valves on the 1100 fire hydrant laterals.

Meeting Increased Demands

Water demands are constantly increasing and a considerable amount of this increase is often hidden in underground leaks. This was found to be true of the Allentown system. Operating records indicated that theoretical capacity had almost been reached and that something had to be done to take care of the war plants and other consumers. Metering was out for the duration and additions to filter plants cannot be built within a few months, even in peacetime. It was necessary then to reduce the pumpage by cutting down on the waste of water from defective house fixtures or from leaks in the underground distribution system.

It was expected that even such an old system as involved in this case would be no different from many others where waste surveys had been conducted with good results, so, early in 1942, the city entered into a contract with The Pitometer Co. for such a survey. This survey was started in March 1942 and covered the entire system, including tests for leakage in the distribution pipes, test of all 4-in. or larger meters in place, test of flow in the gravity spring-water line, 26,000 ft. in length, as well as a test of all pumps for slip and efficiency. The work was completed by December 15, 1942, at which time the management was in a position to evaluate the work done and to form a judgment as to its value. That it was considered a profitable investment is evident from the benefits derived.

A total of 3.17 mgd. was saved by stopping the 190 underground leaks discovered in the mains and services. In addition, 0.158 mgd. of house waste from defective plumbing fixtures was stopped and under-registration of industrial meters amounting to 0.33 mgd. was uncovered.

It should be noted that the house waste, although all domestic services are on a flat rate basis, was very low—eloquently testifying to the frugality of the consumers in this old Pennsylvania community. This amounts to 6 gpd. per service, when taken as an average over the system as a whole.

Effect of Survey

As a result of these savings, the production of water has now been running between 16.5 and 17.5 mgd., notwithstanding the increase of over 1 mgd. in industrial sales of water since early in 1942. This compares with a

consumption of 19.5 mgd. in the months immediately preceding the survey.

Figures 1 and 2 show the manner in which the survey affected the output of the filter plant and the pumping station. At the conclusion of the survey, the demand was 1.75 mgd. under the preceding year, which, added to the 2-mgd. increase in consumption over the preceding year, checks very well with the sum of the measurements of the individual leaks, indicating a saving of 3.75 mgd.

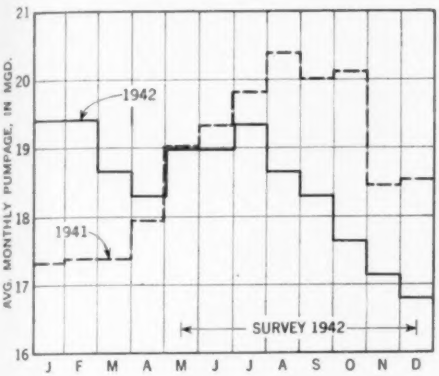

FIG. 1. Comparison of Average Daily Pumpage by Months—1941–42

Defective Valves

During the course of the survey, 200 defective valves were found broken or leaking. These valves had all been in use between 40 and 75 years. Of these, 97 were repaired in 1942 and the remaining ones are being repaired this year. These valves had leaking glands, broken or bent stems, etc. Those in the worst condition were replaced with new valves, but, wherever possible, the old ones were repaired in an attempt to conserve critical materials. Upon completion of this work, the system will be 100-per cent efficient and ready for any war-created emergency, whether due to bombing or to the demands for additional supply by defense industries.

Consumer Ownership of Services

Before discussing the cost of this project, it should be pointed out that all services, from the main to the house, are owned by the property owners, who install and maintain them. When a leak is discovered on such a service, it

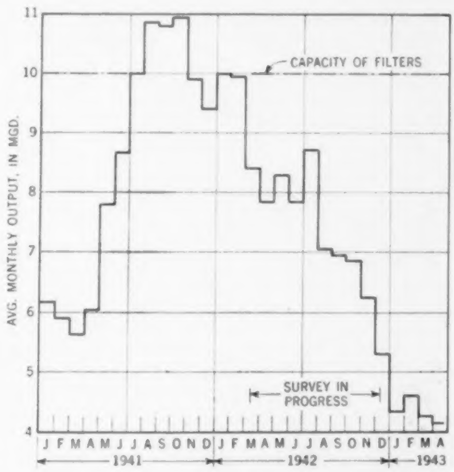

FIG. 2. Daily Average Water Filtered by Months—1941–43

places upon the Bureau of Water the responsibility of showing that the service is leaking. The Bureau must be willing to back up its judgment by paying for any expense to the owner due to its failure properly to locate the leak. Owners are none too willing to believe a service is leaking where the water does not show in the street and, of course, none of the leaks discovered by the survey were coming to the surface. In all, 121 such service leaks were found.

Total Cost of Survey

The total cost of the survey, including the contractor's fee and the costs of repairing leaks on the mains, was $21,083. Cost of all valve replacements and repairs in 1942 and 1943 was estimated at $8427, making the total cost of placing the underground system in 100-per cent operating condition $29,510, or about $172 per mile of main.

The cost of the survey was only 1.58 cents per 1000 gpd. saved, over a period of one year; but as the repairs are permanent, the savings will extend indefinitely into the future and the actual cost will be but a small fraction of this low figure.

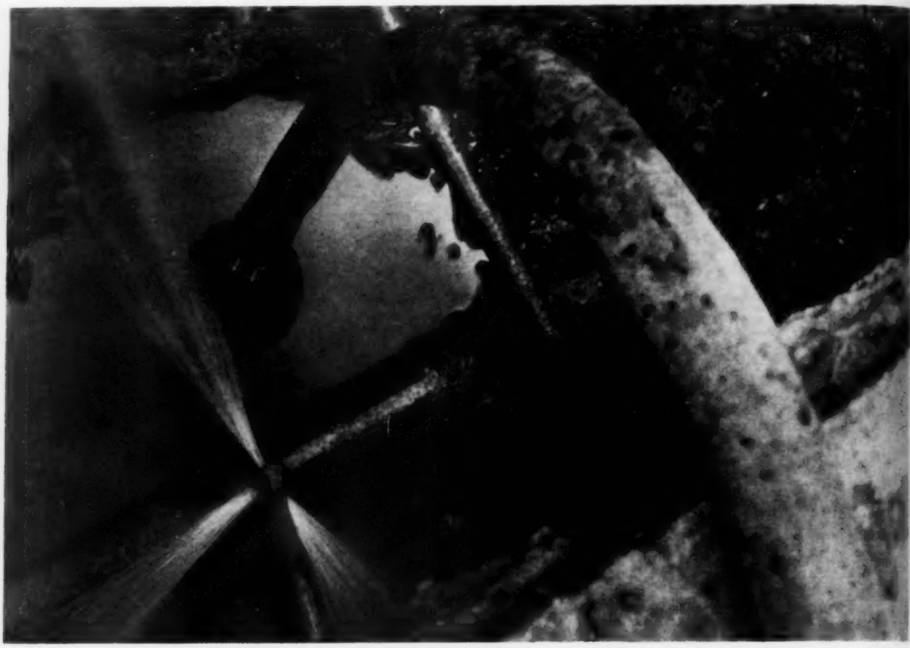

FIG. 3. A Broken 3-In. Main at a $\frac{3}{4}$-In. Driven Ferrule, Discharging 100,000 gpd.

The $21,083 item included the house-to-house inspection costs, amounting to $2750. This figure should be deducted to estimate costs on a system which is entirely metered. For this expense of $21,083, about 3.5 mgd. were saved, involving not only pumping and purification costs, but plant capacity as well, which, in these days of priorities and "doing with less," is very important. The saving in alum alone was $2500 per year and for coal and electricity $10,000 per year.

It is interesting to note that only two leaks were discovered in the 85 miles of mains installed within the last 25 years. This good records holds true also for the broken valves found, attesting to more careful installation

of mains and improvement in the manufacture of street valves.

Valves Under Pavement

The leaks uncovered and broken valves repaired were located in the older portion of the city, where expensive paving had to be disturbed to get at the leaks and to repair the valves. Very few valves are located in manholes, so the cost of repairing valves—$8427—is high. Replacement of old valves is practiced in normal times, as repair costs exceed replacements.

Summary of Savings

Table 1 is a summary of the savings that have resulted, including an estimate of the possible increase in revenue when all industrial services are metered.

This annual value of lost water plus reduction in pump and filter maintenance costs does not include those intangible values found so beneficial. Most important of these latter was the ability to put off for the duration those expensive enlargements to meet demands created by the times. It provided a "worm's eye" view of the conditions of all underground structures.

FIG. 4. 8-In. Joint Leak, Discharging 80,000 gpd.

Improvement in Records

Thus, it was found that the survey was of much value to the personnel in getting data on the operation of all the street valves and the location of lost mains and services. It is known now

TABLE 1

Summary of Water Losses Measured in Amount of Water and Dollar Revenue

Type of Waste	Amt. of Water	Annual Value
	mgd.	*Note* †
Underground leakage		
Main leaks (42)	1.596	$46,311
Hydrant leaks (3)	0.032	
House service leaks (145)	1.544	
House waste	0.158	2,307
Unauthorized use	0.290	4,234
Under-registration of industrial meters	0.330	4,818
Increased revenue from industrial flat rate accounts	0.816*	11,914
Total	4.766	$69,584

* This figure represents that portion of present use for which existing flat-rate charges provide no payment.

† All based on meter rates of 4 cents per 1000 gal.

that, if the city is bombed and mains are broken, the sections affected can be duly segregated, so that the minimum inconvenience will result.

Publicity for Program

The work as it progressed had a beneficial effect on the consumers who noted its progress through the local press, which co-operated by publishing, from time to time, accounts of the total water being saved, together with pictures of the large leaks found. Through this, the citizens became leak conscious and their co-operation was secured in stopping leaks in homes, a fact which is evident in the remarkably low amount of house waste found.

From all indications, the demand for water in Allentown has, in 1943, been rolled back five years.

The Problem of a Diminishing Demand at Marshalltown, Iowa

By H. V. Pedersen

MARSHALLTOWN, Iowa, normally a beautiful, peaceful, leisure-loving community of nominally 20,000 population, located on the Iowa River in the very heart of the most fertile agricultural state in the union, is contributing its share to the war effort. It is sending its young men, doctors and dentists to every branch of the armed forces, serving in every corner of the globe. It is also sending many of its skilled workmen to industries in other cities. Its own industries are producing items used in fighting equipment and are continuously training new men to do precision work. Citizens have subscribed to their quota of bonds and all the drives for scrap have exceeded expectations.

The Water Works Department of Marshalltown too has contributed its bit. It has saved critical material by not laying a single foot of water mains since Pearl Harbor and neither has it added a single item to its stock. It has patched up worn out boilers which should have been replaced this year and has torn out pipe lines here and there in the pumping station in order to salvage valves and fittings needed elsewhere. It has reduced its number of regular employees in an effort to offset increased costs of coal and lime. It is permitting a large part of its lawn to grow to seed this year in order to conserve on power lawn mower equipment. Essential pumping equipment is watched more closely than ever to prevent breakdowns. In maintenance work, everything is welded that can be welded. Even water meter cases, distorted from effects of freezing, are being hammered back into shape and put in service.

But in spite of the fact that most of the industries of Marshalltown are working at normal capacity and retail business is fairly good, the city has been and still is loosing population and this loss is showing up to a disadvantage in the Water Works Department. Water consumption has fallen off and income from sales of water has decreased. The total amount of water pumped in 1942 was 10 per cent less than in 1941 and the income decreased nearly as much. On the other hand, operation costs increased more than 10 per cent due to increase in labor and materials. Contrary, therefore, to the experience of many water departments in thickly populated industrial areas which seem to be suffering from rapid expansion and are worrying about how to keep up with

A paper presented at the Superintendents' Prize Contest Session on June 17, 1943, at the Cleveland Conference by H. V. Pedersen, Supt. of Water Works, Marshalltown, Iowa. This paper was awarded Fourth Prize.

the added demand of water consumption, the Marshalltown Water Department is suffering severe pains from entirely opposite causes.

Although the Water Works Management is not extremely alarmed over this situation at the present time, it is, nevertheless, much concerned and is trying to figure out what should be done in the event expenditures should overtake or forge ahead of income in the immediate future. It must be realized that if expenditure for bare necessities is permitted, war or no war, to exceed water works income for any length of time, it can only result in serious financial difficulties. If the war should last for two or three more years as some authorities think it will and if inflation should aid in forcing expenditures to increase beyond income, then the problem will resolve itself to this: Will it be better to neglect the water works and permit it to run down at the heel, so to speak, in order to keep expenditures on a level with income or should a raise in water rates be considered to increase income?

It may seem nonsensical to look far into the future and to worry when the war will be over or whether inflation will get out of control. Some men say there is no danger of inflation. Yet on the other hand there are many just as smart and far-sighted men who say inflation cannot be avoided. The information that comes out of Washington is such a jumbled mass of contradiction that it is difficult to know what to believe. No one really knows whether the attempt to stabilize prices will be successful. One man's guess as to the future is no better than another man's guess. It may be that the training of a water works man does not qualify him to be a judge in such matters, but it is our guess that the war will last over two years and that prices of all commodities will go much higher before the war is over.

But there is not any guess work in regard to the effect the war has had so far on the cost of living and the corresponding increases in income. It is not a question of whether the Allies will win the war for there is no doubt as to the final outcome, but there is a question of whether every other income in the United States should be permitted, in the meantime, to increase to meet higher costs except the income of water works departments which are experiencing a serious drop in pumpage as a result of loss in population. Just how much of a financial beating should a water works be expected to take before it is considered good water works practice to holler about it, or how long should any city permit its water works to operate in the red before doing something about it?

It may be that Marshalltown is the only city in the United States suffering from population shrinkage pains and that this water works is the only one worried about operating in the red, although if the truth were admitted there may be many more. If Marshalltown is unique in that it is the only forgotten city then it must face and solve its problem alone. If, however, Marshalltown is representative of a much larger group of cities located in non-war-production areas, all of which face substantially the same problem, then this group should seek some means by which each might benefit from the mistakes and advice offered by the other.

There is an old saying which expresses the idea that where someone gains some other loses. People have been and still are moving away from the smaller cities by the thousands seeking jobs with big pay in the indus-

trial centers of our country, leaving those who remain at home to struggle along as best they can on little incomes. There may be all sorts of substitute water works materials developed and many ingenious ways perfected to aid those water works departments striving to take care of this great influx of people seeking war jobs, and most of these water departments are to be commended for the fine way in which they have handled a tough job, but what good are all the substitute materials to that group of unfortunate cities which won't have the money to buy them or which are forced to sit idly by watching while ghost-like shadows slowly cross Main Street.

The only apparent solution to the population shrinkage and resultant decrease in water works income seems to be a raise in water rates. But there is no denying that raising water rates would at first be very unpopular and would require a lot of explaining in view of the fact that many water works departments in war production areas are prosperous as a result of increased water consumption. But if there is any other way of properly maintaining a water works without worrying over a shrinking income it is hoped someone will come to the rescue.

So far the Water Works Management of Marshalltown has met with a few representative groups of men to discuss this problem and more such meetings are scheduled. If conditions actually become acute as the war progresses, it may be necessary to take the entire population into its confidence. It is hoped the approaching storm might be weathered without tampering with rates, but the most optimistic must concede that where dark clouds are gathering it is better to be fully prepared than to sit complacently by and be engulfed.

How the Meter Division Met Wartime Emergency Conditions in Elgin

By LaVerne Trentlage

THE Water Meter Division at Elgin has made three contributions to the War cause by direct saving in "fuels and critical materials" as described by the WPB.

100 Per Cent Elimination of Meter Reading "Pick-ups"

Our two meter readers would net 720 mi. of driving per month for picking up "missed" readings. At that rate of driving, in a little over 14 months, eight recapped tires would be necessary. Another 14 months would demand the same in recapped tires. Since the fuel conservation program, both the "mileage and pick-ups" have been completely eliminated resulting in a diminishing demand for rubber, motor and ignition parts.

However, to compensate for the number of meters "missed," a 1-cent postal card is left in the consumer's mail box. This offers the consumer the privilege of reading his own meter, then only mailing the card to the Water Office. Failure to return the card automatically assures the department the right to estimate the bill.

On one side of this postal card are pictures of two actual size register-faces or dial plates—round and straight reading. This allows the consumer to fill in the reading on the register-face that corresponds to the register-face on the meter. On the round reader, merely the "position of the hands" is indicated; the Meter Division does the reading. The results have been:

1. Majority of consumers favor this program.
2. About 22 per cent of the daily "reads" are missed, and of this number about 30 per cent mail in their readings.
3. The opinion of our office is that this program is most satisfactory under existing conditions.
4. Should an address be missed four times in succession a night call is made.
5. Approximately $7 is expended monthly for post cards.
6. The number of "faulty" readings by the consumer is surprisingly low.

Rattle Barrel

In cleaning meter bottoms on a wire brush, electrically operated, extra help was usually hired. Fifty bottoms were cleaned at a time. The cost per bottom was $.094, or $4.70 for 50 bottoms. To clean 700 bottoms (yearly average) would cost $65.80.

Now, due mainly to shortage of labor and the wartime difficulty of obtaining

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A paper presented in the Superintendents' Prize Contest on June 17, 1943, at the Cleveland Conference by LaVerne Trentlage, Supt. of Meters, Elgin, Ill. This paper was awarded Fifth Prize.

It is becoming increasingly difficult to gain entrance to read meters. Kindly FILL IN THE NUMBERS if your meter corresponds with Fig. 1, or PLACE POSITION OF HANDS should it resemble Fig. 2. Mail or deliver this card to the office. Failing to receive same, your bill will be estimated. The next quarterly reading will automatically adjust itself. Thank you for your co-operation.

Fig. 1

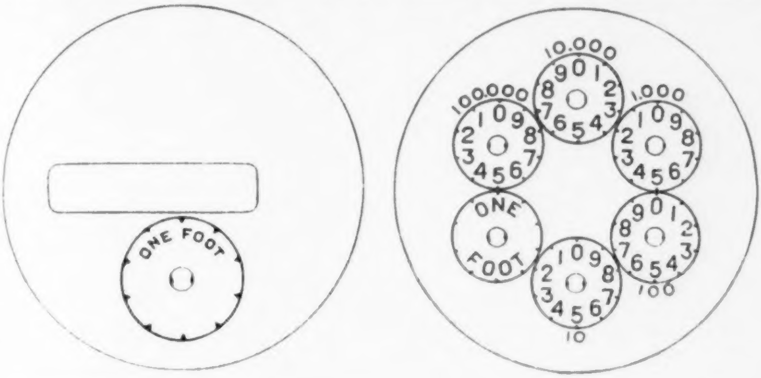

Fig. 2

Postal Card for Self-Reading at Elgin, Ill.

the special brushes, a Rattle Barrel was devised to operate like those used in foundries. The main ingredients are: an old washing machine motor and stand, one 5-gal. oil drum, 700 jacks, belt, 2 bearings, and one coat of aluminum paint. After turning and churning for two hours, 50 bottoms are now cleaned perfectly and without the aid of wire brushes or any manpower. The cost was immediately reduced from nearly \$0.10 per bottom to around \$0.015 per bottom; or, it would cost only \$10.50 to clean our yearly average of 700 bottoms. Under the old system a new brush was required for every 88th bottom.

The cost of this barrel was \$25 in materials and it will last indefinitely.

Grinding-in Measuring Chambers and Disc Pistons

The savings made in this particular field in both "dollars and critical materials" has been no less than spectacular. Although we did not invent this method, we do take great pride in the present state of efficient development in Elgin. We need hardly recall that the materials found in chambers and rubber disc pistons are classed by the WPB as "very critical materials."

Grinding-in actually *renews* measuring chambers, and regardless of age, whether they were manufactured in 1906 or 1920 or 1939. When properly executed, and using the proper material which is the *secret,* or the difference between success and failure, this method will make the chambers register sensational "low-flow" accuracies (providing the rest of the meter is, and can be, repaired and all units are properly aligned).

As is always the case, the only proof of a good meter or a good repair job lies in the $\frac{1}{4}$-gpm. flow accuracy gained. Of 84 residential meters of which *all* were manufactured *prior* to 1920—yes, some back as far as 1910, 1908, and 1906—and as each original measuring chamber was salvaged due to being

properly ground-in and repaired, their accuracy was recorded at:

1-gpm. flow as 99.1 per cent
$\frac{1}{4}$-gpm. flow as 89.3 per cent
$\frac{1}{8}$-gpm. flow as 82.1 per cent.

If it were not for this method of grinding-in, those 84 chambers would have been "junked" and an order placed for a like number of new units costing \$3.13 or a total of \$262.92.

During 1942 we *saved* 509 potentially worn out chambers. Grinding-in *renewed* them.

During 1943, we have a fine start on attaining an objective of repairing 700 meters which have never been removed since original installation. Under the old routine at least 500 chambers would have been discarded, and a like number of new units purchased at a total cost of \$1565. Because we are not going to purchase 500 new chambers, we shall *save* the potential expenditure of \$1565 *plus* a saving of 750 lb. in what the WPB describes as "very critical material" which can now be used elsewhere to aid the cause.

Besides the grinding-in program saving and renewing measuring chambers, it does likewise with the "three-piece disc piston." In 1942, out of one group of 314 meters repaired, 120 disc pistons were completely salvaged at a total cost savings to the Water Department of \$150. Because we are not going to buy 120 *new* disc pistons, a further saving of 31 lb. in what the WPB describes as "very critical material" can be used elsewhere to aid the cause.

Out of every 100 disc pistons, 99 are saved 100 per cent (all three pieces) if manufactured in the neighborhood of 1927. Prior to those years, the percentage of new ball-sets only will enter into the picture to the extent of about 5 per cent, and they cost \$0.42 per set.

In conclusion: We are proud that we are *Saving, Renewing,* and *Co-operating* with our Government in a *First Class Way!*

Financial Problems of Civil Defense

By Henry Berry

THE interval between the Munich Meeting in 1938 and the outbreak of war in 1939 provided a breathing space in which to make some sort of preparation against inevitable German aggression. Britain's public utilities and municipalities used the time to good purpose for defensive work against aerial and other forms of enemy action.

There was not much information, other than from the experiences of the Spanish Civil War, on which to go. Some people, who had been to Barcelona and Madrid during the bombing of those cities by German and Italian airmen under Franco's command, had come back with startling stories, and the impression gained ground that no civil populations would be able to stand against the might of the Luftwaffe.

Still, preparations had to be made, preparations in the shape of communal air raid shelters, air raid shelters in large public buildings as well as in smaller houses. Services—known today under the title of Civil Defense—had to be arranged. These comprised auxiliary fire services (for at that time the fire services were within the province of various municipalities up and down the country and had not been combined into a National Fire Service); rescue, shoring and demolition services, ambulance squads, air raid warden's services, and other emergency measures. By 11 A.M. on September 3, 1939, when Britain was again plunged into war, these services, in a greater or lesser degree were ready for action.

True, they have since had to be modified in the light of experience; some were found to be too elaborate and were cut down; some had to be expanded; all had to be adjusted; but right well did they stand the test when the blitz burst on Britain in August, 1940.

So much for local authorities. What of public utilities? These, especially gas, water and electricity undertakings, were vulnerable. On them the continuance of the industrial life of Britain depended, and on water undertakings, in particular, human life also depended. Preparations had to be made.

London's Metropolitan Water Board will serve as an example of the preliminary work carried out. A special small Sub-Committee was appointed, its importance being recognized by the fact that the then Chairman of the Board, was its first Chairman.

A contribution by Henry Berry, Chairman of the Metropolitan Water Board of London, Eng.

This paper has been made available for publication through the courtesy of British Information Services, New York.

Problems that had to be visualized were diverse in character. Preparations had to be made for pumping to continue should any of the Board's pumping stations be knocked out. Mobile plant to the value of several hundred pounds was purchased, tested, and kept in readiness for the breaking of the storm.

Planning for Main Dreaks

To cope with the possibility of broken mains and consequent fouling of water in those mains, a fleet of mobile chlorinators had to be provided. With other measures, they made a sure shield for London against the typhoid scourge.

Stocks of spare mains, valves, and jointing material were laid in. Experiences during many months of blitz proved the wisdom of this course.

The Board's organization had to be varied and extended; duplication of turncock personnel was the aim, these being key men should damage to mains be experienced. Flying squads of messengers in various parts of the Board's area had to be organized in the light of a possible breakdown in the telephone service. Sleeping accommodation had to be provided in every key point and station in case it was impossible for those in the service to go to and from their homes.

Over and above these, the usual things, such as the provision of air raid shelters, protection of machinery, and a hundred and one others, had to be undertaken.

The justification for the enormous expenditure involved was that through the blitz the Greater London Area had its water in spite of all the enemy could do, and that not one case of wartime typhoid was experienced.

All these things cost money, and the view was freely expressed by both local authorities and public utilities that they in their public capacities were not responsible for any event of war. War fell within the purview of the Government.

In consequence on the financial side there was strong feeling that the whole of the expenditure involved should be met from national funds and not as a charge on local authorities or public utilities. The Government, however, thought differently. Here then were two opposing points of view, and they were settled by a compromise.

Compromise on Financing

It is impossible here to enter fully into the ramifications of the financial aspect. Local authorities, however, obtained grants ranging from 65 per cent, to a larger percentage in the case of the poorer boroughs, of their approved air raid precaution expenditure. In the early days Public Utilities were left out, temporarily.

To their credit be it said that this difficult financial position did not prevent public utilities from going ahead with the necessary work, and ultimately they were granted 50 per cent on approved capital, and in some cases maintenance expenditure.

As time went on and the threatened blitz became reality, certain points emerged more clearly, accentuating other depletions of financial resources that had taken place at the beginning of the war. In the latter days of August and early September of 1939 there had been a considerable exodus from the larger British cities, especially those toward the east of the country.

As far as possible all school children had been evacuated, and this meant a

general exodus of teaching and education administrative staffs, as well. Many business firms evacuated from the larger cities to smaller and what were presumed to be safer places. This meant closing down schools, business premises and houses. Every one of the premises closed down meant a loss in rateable value to the local authority and to water authorities. It also meant a loss on the score of lessened supply to gas and electricity authorities.

On the other hand, the wartime demands on the last two named utilities to a certain extent compensated for the loss of income due to evacuation. With the coming of the blitz and further reduction in rateable value came a reduction in income to the authorities concerned.

To deal first with local authorities, the natural result of this would have been for sharp increases in the rate in the pounds levied in every area, and especially in the blitzed areas. In other words, those who through force of circumstances remained in the bombed districts would have been forced to bear a much heavier impost in the shape of increased rates.

It is not too much to say that in some of the poorer districts this would have been far in excess of what it would have been possible for many to have borne. Faced with a situation like this the matter was tackled in a commonsense manner. The Government recognized that this situation could not be allowed to develop. On the other hand it could not consent to give *carte blanche* assistance to local authorities.

So the Government made subventions to many of the local authorities in the worst blitzed areas of the country, enabling them to maintain their rates at the same level as before the blitz. This subvention took the form of 75 per cent free grant, 25 per cent to be regarded as repayable after the war.

There is a general agreement concerning the free grant, but there is no such general agreement regarding the repayment of the 25 per cent. Doubtless the matter will be settled in the postwar days, taking into consideration the general situation and the demands on the local authorities.

For public utilities, the situation was rather different, as indeed were the methods of levying charges for gas, water and electricity. The matter was further complicated by the fact that some of the utilities were publicly owned by their municipalities or by groups of municipalities; some were run by joint boards municipally appointed, while certain others were in the hands of private enterprise.

Obviously a Government department could not deal with private enterprise of a profit-making character as it could with publicly-owned bodies of a non-profit-making character. On the other hand the Government could not view with equanimity steep increases beyond the capacity of citizens to pay.

Control of Rates

A further difficulty was a difference in the make-up of price incidence to consumers. To take an example from water undertakings, one of the great northern municipalities charges a rate of, say, 3 per cent of the rateable value on all premises, plus a further rate to those who take the water.

The reason for this is that whether people take the water or not they have

the protection from fire afforded by the fact that the water services are there. There is much to be said for every occupier paying his scot and bearing his lot. Other water undertakings charge a rate per cent on the rateable value of those who take the water, people having their own well supplies thereby escaping water rate.

In view of the complications involved, the Government took the view that while a certain amount of price increase could be allowed, it must not move beyond a maximum which they fixed.

To take the case of my own Authority, it is allowed to charge up to 10 per cent of the rateable value, but if any charge is to be made above $8\frac{1}{2}$ per cent, then the authority of the appropriate Government department must be secured. In the event of 10 per cent not being sufficient, then the local authorities in the Board's area could be precepted in proportion of the rateable value of their areas to make up the deficiency.

The Government and the Board agreed that the rate ought not at present to go beyond $8\frac{1}{2}$ per cent. There have been difficulties with a number of public utilities and reserves have had to be brought into action, but generally speaking there has been reasonable price control throughout the range of the three public utilities—gas, electricity and water.

The policy of the British Government has been to control the price of municipal and other services to the citizens, as in the case of food. What the financial postwar problems will be it is too early to predict, but problems there certainly will be.

However, victory is the first essential, for without victory other problems would fade into insignificance. With victory—and the peace that victory will bring—financial and other problems involved can be faced with the same spirit of grim determination that has characterized the administration of Britain's local authorities and public utilities during the present struggle.

Water Supply Practice in Army Training Centers

By Lewis H. Kessler, V. Bruce Sundstrom and Arthur O. Tomek

THE water production and distribution facilities at fixed Army installations throughout the country bear an important relationship to all other post activities. It was necessary that the most modern design standards pertaining to the protection of health, utility service, sanitation and fire protection, be incorporated in the construction of these utilities. Wherever possible, however, design standards have been tempered with economy in the use of critical materials and the dispatch necessary to meet construction schedules. Much is demanded of these installations even though many are expected to be in service for a limited time only. New problems of operation and maintenance have offered a real challenge to engineers. In order to assure continuity of service, maintain efficient operation and improve designs for wartime conditions, the Repairs and Utilities Branch, Construction Division, Office of the Chief of Engineers, has made a careful study of the operating problems at many posts. Results of this study are here summarized for the benefit of the profession.

The passage of the Selective Service Act in 1940, followed by the declaration of war 15 months later, brought about the greatest war construction program ever conceived and accomplished in this country. About eleven billion dollars in new construction has been completed, comparable to 9 times the assessed valuation of the City of Cleveland, Ohio.

Those of you who were in the Capital City during the early hectic days, may recall the banner, "Time is Short." This is exactly what faced the Army and architect-engineers in the planning, construction and placing in operation, within a period of a few short months, complete water works systems to serve military establishments as large as 35,000 population. Many are double that size now. Time did not allow for the thorough exploration of adequate designs, economical developments or complete investigations of the potentialities of existing water sources, as is the procedure in most municipal planning. However, the evidence shows that exercise of keen and accurate reasoning and sound engineering judgment was the rule rather than the exception.

The location of military posts cannot be selected solely on the basis of

A paper presented on June 15, 1943, at the Cleveland Conference by Lewis H. Kessler, Prin. Civ. Engr. (San.): Maj. V. Bruce Sundstrom, CE, Chief of Water Group; and Arthur O. Tomek, San. Engr.; all of the Water and Sewage Unit, Repairs & Utilities Branch, Construction Div., Office, Chief of Engineers, War Dept., Washington, D.C.

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the water supply although some sites were rejected because of the excessive cost of developing adequate water supplies. Cost of land, transportation facilities and other utility service as well as terrain suitable for training purposes are some of the other controlling factors considered in site planning.

More than 1000 waters are encountered at present posts differing in chemical analyses from that of practically distilled water to water containing 2300 ppm. of dissolved solids. An idea of the magnitude of the operating problems can be obtained from the following summary as of December 30, 1942:

Total no. of stations (inclusive of sub-posts)	1,044
Stations using purchased water	334
Stations having some type of water plant	710
Stations having water filtration plants	91
No. of filtration plants	144
Total capacity of filtration plants, *gpd.*	190,757,000
Total pumping capacity, *gpd.*	18,087,156,000
Avg. water supplied, *gpd.**	(over) 500,000,000
Length of mains, 4–30-in., *mi.*†	6,608
Length of services, *mi.*†	2,680
No. operating personnel	(over) 3,000
Operating budget, 1943–1944 Fiscal Year:	
Air force installations	$ 6,078,971
Ground force installations	$11,273,463
Non-recurring maintenance items	$ 1,700,000

* The water consumption is equivalent to requirements of the population of the State of Michigan on a per capita basis.

† The mileage of mains and services total about three times the distance from New York to San Francisco.

Organization

As an introduction to the problems of water works and distribution system operation, a few words should be said on the organizational machinery involved.

In March 1941, a section was reorganized in the Construction Division of the Office of The Quartermaster General to provide for the maintenance, repair and operation of all buildings, roads, runways, grounds and utilities in Army camps and cantonments. This was later expanded into a Branch—the Repairs and Utilities Branch. On December 16, 1941, by Act of Congress, the whole Construction Division was transferred from the Office of The Quartermaster General to the Corps of Engineers. There was no radical change in methods or channels of operation, except that the Zones were abolished and the Division and District Offices of the U. S. Engineers took over the work. The Engineers had always been charged with construction of Air Corps stations. The officer in charge of utilities work at the various Service Commands is now the Division Engineer with assignment of Director of Real Estate, Repairs and Utilities. The Post Engineer is responsible for the satisfactory performance and operation of the water works or treatment plant under his jurisdiction. As to plant operation, the chain of command is as follows: Commander of Army Service Forces (formerly Services of Supply), Service Commander, Post Commander and Post Engineer.

Analyses of operating data from field reports were started in August 1941 by the Water, Sewer & Services Unit, Repairs and Utilities Branch, OQMG. Operating data were submitted by the field on three forms so designed as to serve also as operating logs at the plants. One form was used for purchased water supplies and booster stations, one for well water supplies and the third for surface sup-

plies and filtration plants. Records of bacteriological analyses and other pertinent data were thus collected and used in the preparation of portions of this paper as well as sanitary reports submitted to the Office of The Surgeon General, U.S.A. Although the regular monthly reports are no longer submitted to the Office of The Chief of Engineers (OCE), a new brief monthly summary data form for compliance studies will be required.

There exists a close co-operation between the Sanitary Corps Officers of the Medical Corps and the Corps of Engineers on all matters vital to the health and welfare of the armed forces. In accordance with Army regulations, the Medical Corps is charged with certain advisory functions relating to the potability of the water supply. Actual operation is supervised by the Post Engineer and assistants.

Design of Units

The Engineering Branch of the Office of The Chief of Engineers (OCE) is charged with the publication of the *Engineering Manual* and general review of all construction plans and policy formation as a guide to architect-engineers and District Offices. Chapter VI on Water Supply, Distribution and Storage is being revised, but the design factors disclosed herein are those encountered at existing posts. The allowance of 55 gal. per capita daily (gpcd.) during World War 1 cantonment construction was found to be inadequate. The design units were increased in accordance with the units shown below, because more extensive use is made of sanitary fixtures in barracks and mess halls. Vehicle and plane washing, irrigation for soil covering at certain Air Corps stations, laundries and refrigeration plants are also contributing factors.

Airfields, Camps and Cantonments Mobilization Type Construction	100 *gpcd.*
Theatre of Operations Type Construction	70 *gpcd.*
Permanent Army Posts	150 *gpcd.*
Armored Division	150 *gpcd.*
Hospital Areas	150 *gpcd.*
Animals	25 *gpd./animal*
Plant, Port and Storage Projects	35 to 50 *gpc./hr./shift*
Resident Person	100 *gpcd.*

In March 1942, provisions were made for unforeseen contingencies, in the form of reasonable population increases and unusual peak consumption by multiplying the foregoing per capita rates by the following capacity factors:

Specified Project Population	*Capacity Factor*
10,000 and less	2.00
20,000	1.50
30,000	1.25
40,000	1.10
50,000 and over	1.00

Many posts have been or are now being expanded, and at others the design housing capacity has been materially increased by "double bunking." This decreased the allowable floor space per man from 60 to 40 sq.ft. Although some plants have been altered and extended to assure adequate water facilities, experience has proved the adoption of the capacity factors above to be a wise move. Unforeseen circumstances sometimes influence changes in the design factors for a particular post. For instance, with the activation of WAAC Training Centers, the per capita water consumption has been found to have increased as much as 50 per cent.

	No. Concurrent Fires	gpm./Fire	Hours Duration
Mobilization Construction (Two Story)			
Pop. 1000 to 6000	1	1000	2
Warehouse Area	1	1000	4
Pop. 6000 and over	2	1000	4
Warehouse Area	1	2000	4
T.O. Construction (Single Story)			
Pop. 1000 to 6000	1	750	2
Warehouse Area	1	750	3
Pop. 6000 and over	2	750	3
Warehouse Area	1	1500	3
Dispersed Layouts	1	500	2
Small Stations			
Pop. less than 300	Incidental to domestic requirements		
Pop. 300 to 499	1	150–250	2
Pop. 500 to 999	1	500	2
Station Hospitals			
Bed Capacity—Less than 250	1	1000	2
250 to 499	1	1000	3
550 to 999	1	1500	3
1000 and over & Gen'l Hosp.	1	2000	4
Port & Storage			
Less than 1,000,000 sq. ft.	1	2000	4
Greater than 1,000,000 sq.ft.	1	4000	4
Tent, Hutment Camps, having warehouse latrines and mess buildings only.	Use T.O. Construction requirements unless dispersed layout applies.		

At some of the smaller posts, the size of mains and storage capacity for fire protection have caused a problem in maintaining the sanitary quality of the water because of the small domestic use. Post Engineers are encouraged to resort to periodic flushing of the mains as a corrective measure.

Figure 1 is a typical water consumption curve. It is based on the first complete data obtained at a post activated since the Selective Service Act.

In the planning and development of water supplies for Army installations, it has been the general policy to give preference to that supply having the lowest first cost, even though the development and operation cost over a 5-year period may be higher. Purchased supplies are given first consideration. Negotiations are made for the purchase of water where the available supply is adequate, and meets U.S. Drinking Water Standards. In a few places enlargement of these facilities has proved feasible; likewise, in certain cases in the interest of conservation and the public welfare, the government has entered into a few revocable contracts with other agencies for the sale of surplus water from government controlled supplies. Ground water, where available in adequate quantities, is invariably developed more quickly and at a lower first cost than surface

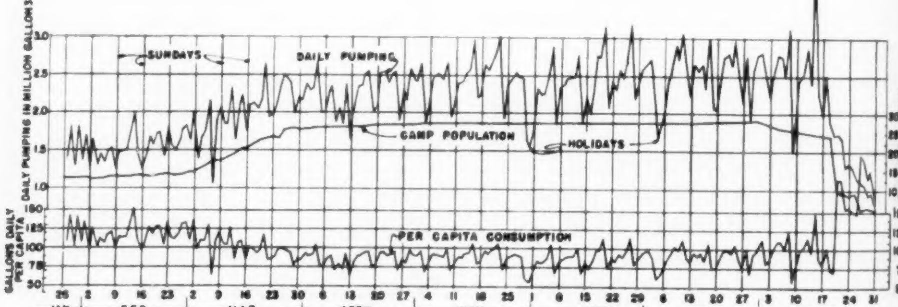

FIG. 1. Typical Curves Showing Population and Water Consumption for an Army Cantonment

supplies. The latter is resorted to when other sources are not available or when underground supplies are neither reliable nor feasible. Although to date only two complete failures of well supplies have been experienced, a number of well fields through interference or other causes are subject to constant surveillance.

Well supplies are designed for a minimum of two wells with half the units equipped with combination power heads and standby gasoline engine drives. Although no dual filter units are provided either for well or surface supply treatment, filters are designed to supply 150 per cent of the total daily requirements over a 24-hr. operation period at a filter rate of 2 gal. per sq.ft. per min. For flexibility in operation, a minimum of two units is required. Layouts are arranged at the site to permit extensions to sedimentation and filtration units at a minimum cost of construction and use of critical materials.

While it is true that the Army has installed softening equipment at various posts for the treatment of water for boiler plants, hospitals, laundries and, in fewer instances, kitchen uses, many of these installations were approved before materials and equipment became critical. New installations are now rigidly controlled and have been approved only where high temperatures and chemical properties of the water result in scale, corrosion, or where dictated by economy in the operation of laundries (water above 5 gpg.). In general, conditioning of boiler feed water is accomplished by internal treatment and only in special cases of extreme hardness is softening equipment authorized. Where a water supply contains hardness in excess of 400 ppm. small zeolite softeners are authorized for the hot water installations of mess halls. Some posts have elected to contract for soft water service for mess halls, using private or company funds. Regeneration or exchange service is furnished by the contractor.

In view of the existing War Department policy restricting the use of water softening equipment, the Army Service Forces is attempting to correct the erroneous opinion held by many, and the misleading advertisements, to the effect that extravagant use of critical materials and equipment is being made by the Army with disregard for civilian requirements.

Water supplies at fixed Army installations are summarized by the following types:

Purchased supplies	38.2 per cent
Well supplies	41.2 per cent
Surface supplies	20.6 per cent

The average per capita consumption has been reduced from about 102 gpcd. to 69.8 gpcd. in the continental United States. Table 1 is a summary of water supply by Service Commands. It represents only data we are positive are correct. While it does not include all posts or water works, the survey as shown will not change radically as to consumption or per cent of population served. From other studies, there appears to be little variation in water supply requirements for posts in southern localities as compared with those located in the north, except in isolated cases where extra water is required for irrigation and air-conditioning. One or two posts carrying distribution pressures of 100 psi. have experienced higher per capita use. The controlling factor as to the variation in per capita use of water is the type of post. Posts

having large numbers of tactical motorized equipment or planes experience greater usage of water.

Intake structures and raw water low-lift stations depend upon local requirements. Pumping units are fixed by the number and size of filter units. Three motor driven pumps are required to provide sufficient range in capacity to permit the filtration plant to operate at rated capacity with the largest pump out of service. Fifty per cent of the normal capacity is provided by standby gasoline-engine-driven pumps.

vated tanks or materials of construction have not been available within the completion date. Elevated storage has permitted the installation of two motor-driven pumps, each capable of supplying the daily demand, a third pump of one-half daily demand and one gasoline-engine-driven pump for one-half of the daily demand. For direct pressure systems, several gasoline-engine-driven pumps are required to meet peak consumption and maintain fire flow rates.

Dual water systems are permitted in

TABLE 1

Summary of Army Water Supplies—October, November and December 1942

Service Command	No. of Posts				1000 gpd. Water Used				Total Pop. Served	Avg. Cons. gpcd.	% Pop. Served		
	Total Tabulated	Purchased Supplies	Well Supplies	Surface Supplies	Purchased Supplies	Well Supplies	Surface Supplies	Total			Purchased Supplies	Well Supplies	Treated Supplies
1	38	29	8	1	3,448	6,152	4,026	13,626	184,545	73.8	29.2	53.4	17.4
2	34	25	9	2	7,696	4,378	3,390	15,464	233,468	66.5	52.1	27.6	20.3
3	43	26	10	7	8,461	3,722	9,452	21,635	277,976	78.2	43.1	13.3	43.6
4	110	55	47	18	23,737	17,475	29,337	70,549	1,070,761	65.7	35.8	34.3	29.8
5	18	14	2	5	728	464	837	2,029	31,841	63.8	47.9	10.5	41.6
6	20	15	4	2	3,343	2,738	1,502	7,583	125,332	60.7	45.7	32.7	21.6
7	60	39	18	6	11,144	8,079	7,122	26,345	360,912	72.3	50	23.2	26.8
8	104	56	43	8	24,832	25,718	3,444	53,994	862,715	62.5	52.9	41.5	5.6
9	118	55	54	9	13,014	33,902	8,465	55,381	664,215	83.5	27.2	60.2	12.6
Total	545	314	195	58	96,403	102,628	67,575	266,606	3,811,765	69.8	41.2	38.2	20.6

Distribution Systems

Minimum pipe sizes and reserve pumping capacity have been required because of high level storage either in surface reservoirs on high ground or elevated tanks. Since November 1942, the trend is toward increased surface storage. All cantonment projects call for high and low level storage of not less than 50 per cent of the total daily demand or the required fire demand. Direct pressure systems are found only where military use will not permit ele-

rare cases only. A few older posts have salt water fire distribution systems. Inter-connections between a potable and a non-potable supply are never permitted, and the installation of back-siphonage preventers of approved designs has been made mandatory at all owned and leased facilities.

Fire flows for the garrison, warehouse and hospital areas have largely governed the size of mains. Garrison areas are designed at $2\frac{1}{2}$ times the daily average per capita use with pressure

above 30 psi. Fire flows are based on residual pressures of 5 to 10 psi. where pumping engines are available. Friction losses in pipes are computed using a coefficient of 100 in the Williams-Hazen Formula, except in long supply mains.

Fire hydrants are spaced about every 400 ft. in barrack areas and so located that fire streams from a maximum of 300 ft. of hose connected to at least two hydrants can be played on each building. The warehouse areas and aircraft hangars require hydrant spacing of 300 ft. with hydrants located 50 ft. from the nearest building. In no case are hydrants spaced closer than 25 ft. from a building or runway.

Valves are located first to control reasonable sized areas of the post, approximately every 5000 ft. on long supply lines, at intervals of about 1200 ft. on main loops or feeders and on all the primary connecting branches. Valves on hydrant branches are not required except where unusual traffic hazards are likely to be encountered or where hydrants are installed on the main loops or feeders.

Storage tanks are located near centers of water demand and establish hydraulic gradients of not less than 93 ft. at the highest ground elevation. Occasionally topographical variations produce more than 231 ft. in low areas, and where possible, these areas are isolated and pressure reducing valves are used. In a few cases, storage facilities are provided for a two level system when the gradients are too high.

In port and storage projects of less than a million square feet, 500,000-gal. reservoirs with elevated storage of about 50,000 gal. are common. In like projects of greater than a million square feet, the reservoirs usually total 1,000,000 gal. with 50,000-gal. elevated storage.

Water Plant Operation

Filtration Plants

Table 2 shows design units and operating requirements of 5 of the 91 filter plants. In general, no serious operating difficulties are encountered. Several plants having flash mixers with rapid changes in quality of water have caused trouble. Operators of plants having accelators report the units are difficult to control especially under slight changes in temperature of water. The sludge blanket type of clarifiers have been found to require more chemicals than originally recommended by manufacturers.

A few pictures convey some idea of the quality of construction, design and installations at several posts. Features of the Army's largest plant, which is at a permanent North Carolina post, are shown in Figs. 2–4. Figures 5–7 show plant at a Tennessee post. Figure 8 shows the primary settling tank with clarifier, part of the filters and operating table at a California post treating a deep well supply in the bed of a river protected from sea water by a long earth dike. Because of winds and blown sand, the filter operating gallery is being enclosed.

The Army has many impounded supplies. Figure 9 shows the spillway and intake of an impounding reservoir at a post having high carbonate water. A tunnel and pipe line from an adjacent drainage area also feed this reservoir with a water high in sulfates and low in alkalinity. The chemical storage and feeder building, for treating this mixed supply, and the open air operating gallery and settling basin are illustrated in Figs. 10 and 11. Some difficulties

TABLE 2

Design Units and Operating Requirements of Five Filter Plants

	Post 46		Post 47		Post 48		Post 22		Post 8	
Population	32,835		13,062		33,934		67,604		26,200	
Date of beginning	1917		1918		1941		?		1941	
Improvements, additions	1940		1940		—		1941		—	
Source of supply	Patuxant River		Brick Kiln Creek		1 well		Upatoi Creek		Elk River	
Nominal capac. of plant, mgd.	4.0		4.0		4.0		7.0		3.0	
Water treated, *1000 gal.*	3189		1693		2501		7395		2528	
Water produced, *1000 gal.*	3104		1645		2431		7134		2327	
Cost per 1000 gal.	\$0.075		\$0.067		\$0.0879		\$0.03		\$0.056	
Consumption, *gpcd.*	96		126		72		105		97	
Aerators			Spray type aerators		Coke tray aerators					
Chemicals:	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.
Lime, lb./day	12	—	—	129	2759	—	655	1110	64.1	—
Alum, lb./day	450	—	527	—	352	—	2510	—	519.3	—
Carbon, lb./day	55	—	37.2	—	0	—	—	—	27.9	—
Chlorine, lb./day	32.7	38.8	27.3	30.6	0	19.3	96	90.5	22.1	—
Ammonia, lb./day	—	—	—	9.83	0	5.44	—	18.5	7.7	—
Odor	1	—	1.4	—	—	—	1	—	—	—
Color, *ppm.*	10.2	3	73	4.3	—	—	93.7	11.3	—	—
Turbidity, *ppm.*	69	1	17	—	80	—	25	—	134.4	25.7
Total alky., *ppm.*	28.5	34	28.1	24.7	184.3	84.4	7.4	22.1	62.6	55.4
pH	6.9	8.1	7.6	8.8	6.8	8.09	4.97	8.8	7.5	7.28
Total hardness, *ppm.*	69	97	34	58	228	134.8	8.7	53.2	78.3	80.6
Iron as Fe, *ppm.*	0.52	0.1	1.07	0.013	3.21	TR	—	—	—	—
CO_2, *ppm.*	—	—	—	—	72.5	—	6.4	—	—	—
Residual chlorine, *ppm.*	—	1.19	—	1.0	—	0.8	—	0.45	—	0.53
Mixing Chambers:										
Type of chem. feed	dry &	soln.	dry &	soln.	dry &	soln.	dry		dry	
Alum added, *gpg.*	1.0	—	2.2	—	1.0	—	2.39	1.05	1.45	—
Lime added, *gpg.*	0.03	—	—	0.54	7.75	—	0.63	—	0.18	—
Type of baffling	solid with pipe inlets		straight		patented		surface baffle		none	
Type of mixing	flash and velocity		Flocculators		mechanical		Flocculators		Flocculators, Turbo mixer	
Sedimentation Basins:										
Number of basins	3		4		2 (Accelator)		4		2	
Settling time at nom. capac., *hr.*	6.0		4.0		1.08		6.92		4.25	
Method of baffling	end around & straight		end around		patented		inlet & outlet only		inlet & outlet only	
Basins	open		2 open, 2 cov.		open		covered		open	
Length one basin, *ft.*	72.83		86 & 50		33 diam.		98.25		79.5	
Width one basin, *ft.*	40		32 & 26		—		49		32	
Avg. depth one basin, *ft.*	12		10.5 & 12		14		14		14	
Total basin capac., *mil. gal.*	1.0		0.67		0.18		2.0		0.53	
Filters:										
No. of units	4		4		4		14		6	
Size of units, *mgd.*	1.0		1.0		1.0		0.5		0.5	
Dimensions of sand layer, *ft.*	18 × 20		12 × 15 & 20 × 17.5		22 × 16		10 × 18		14.5 × 12	
Depth of filter box, *ft.*	11.5		8.5		14		12		8.83	
Thickness of sand, *in.*	24		28		32		27		30	
Effective size of sand, *mm.*	.45–.50		.45–.50		.40–.50.		.38–.45		.50	
Thickness of gravel, *in.*	18		18		14		15		18	
Maximum size gravel, *in.*	2.5		2.5		2.5		2.5		2.5	
Minimum size gravel, *in.*	0.25		0.25		0.25		0.25		0.25	
Type of strainer system	brass lateral, c-i. manifold		brass lateral, concrete channel		Transite laterals, concrete channel		Wheeler underdrains		c-i. laterals, c-i. manifolds	

TABLE 2—*Continued*

	Post 46	Post 47	Post 48	Post 22	Post 8
Filter Washing:					
Avg. run, *hr.*	47	43	109	30.3	51
Rate of filtration, *mgd.*	125	125	125	125	125
Total units washed per day	1	1.68	0.8	6.03	2.3
Avg. wash time, *min.*	5	16.8	7.3	10.4	5.01
Wash water, *% of total*	1.13	2.49	1.66	2.76	1.78
Rate of wash, *in. rise per min.*	24	24	24	24	30
Agitation of sand	none	none	none	Palmer filter sweep, 8 units	surface nozzles
Height top sand to trough crest, *in.*	30	24	24	27	33
Location of wash troughs	center and ⅙ points	⅓ point	center and ⅙ points	center and ⅙ points	2 at ⅙ points
Wash water tank capac. 1000 gal.	use pumps	use pumps	use pumps	use pumps	use pumps
Filtered Water Reservoir:					
Capacity, *mil. gal.*	1.0	0.562	1.63	1.5	1.0
Open or covered	covered	covered	covered	covered	covered

occurred at this filter plant and at others that have been converted to partial softening. Recarbonation equipment has been inadequate. A polyphosphate was being added, when last visited, in order to stabilize excessive calcium.

The Army uses a number of lakes, both natural and artificial. One such post has a floating raft and an electric-driven pump which deliver algae-free water to a small filter plant. The plant includes a clear well, high lift pump station and pneumatic pressure tank, from which the water is forced eight miles to the post.

Pneumatic Systems

The Army has several pneumatic systems, especially at airfields. At the Texas post plant shown in Fig. 12, the reservoir in the foreground is supplied by deep-well turbine pumps and the booster station with headers, control valves and tank are shown in the background. Maintenance and repair are simplified here.

In typical booster stations, where a post uses a purchased supply, it may be noted that 50 per cent of the capacity of the several sizes of pumps are equipped with standby gasoline engines.

Well Supplies

All problems considered, well supplies have proven the most satisfactory type of supply for Army purposes. Although shallow wells are not always as dependable as deep wells, they usually supply a more desirable water with respect to both chemical quality and cold temperature. Some trouble has been experienced with the pumping of sand, but this has usually been due to improper setting of either the casing or screen, high pumping rates or failure to plug properly the bottom seal in gravel-wall wells. Gravel-wall wells on the whole have proven very satisfactory.

In only one instance has a post been abandoned because of the well water supply. This occurred at a small National Guard Camp where it was not feasible to treat the high chloride content of the well supply. The Army has developed a few artesian wells in the Dakotas and along the Eastern seaboard which are unusual as to pressure, temperature and high mineral content.

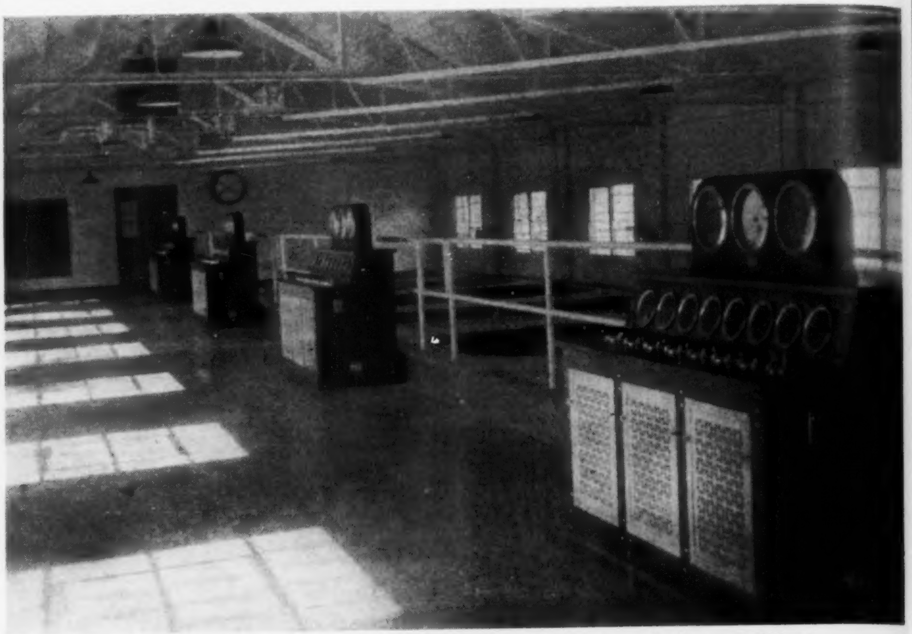

Fig. 2. Operating Tables and Filter Bay at the Army's Largest Plant

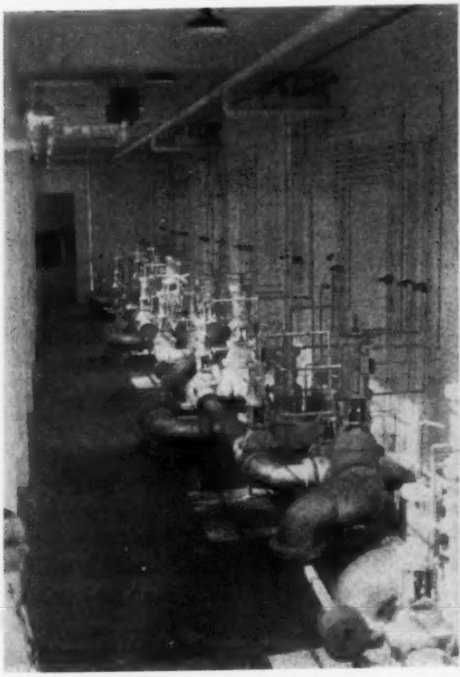

Fig. 3. Operating Gallery

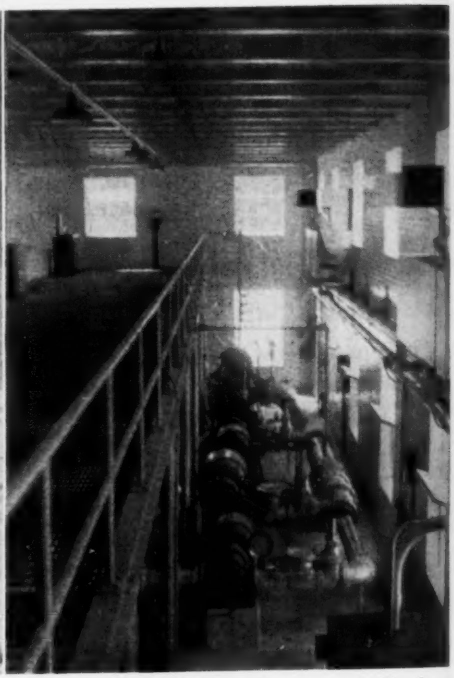

Fig. 4. Wash-Water Pumps and Header

FIG. 5. Filters at a Tennessee Post Provided With Cantonment Superstructure

FIG. 6. Clear Well at a Tennessee Post

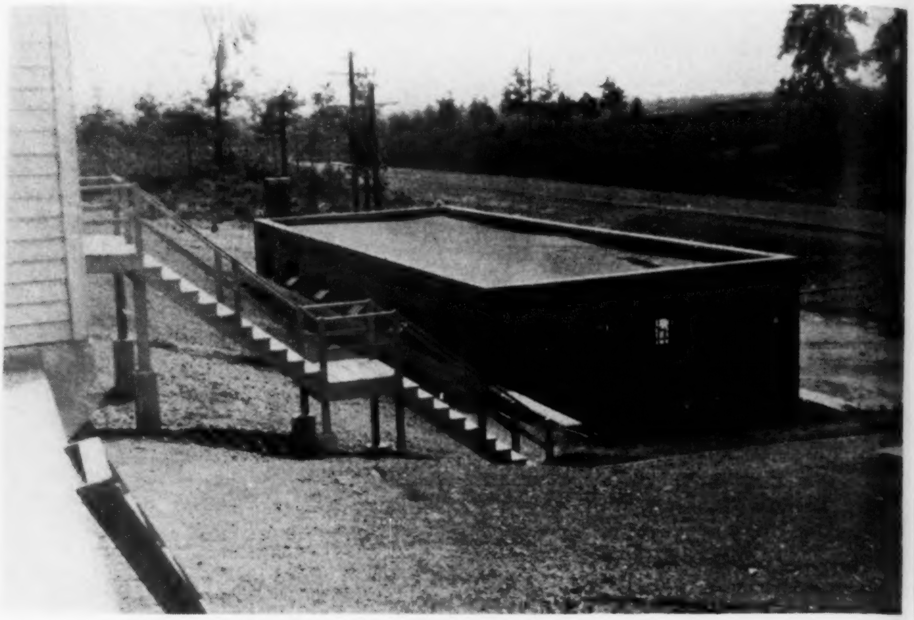

Fig. 7. High-Lift Pumping Station Adjacent to Filter Building

Fig. 8. Primary Settling Tank With Clarifier and Part of Filters and Operating Table at California Post

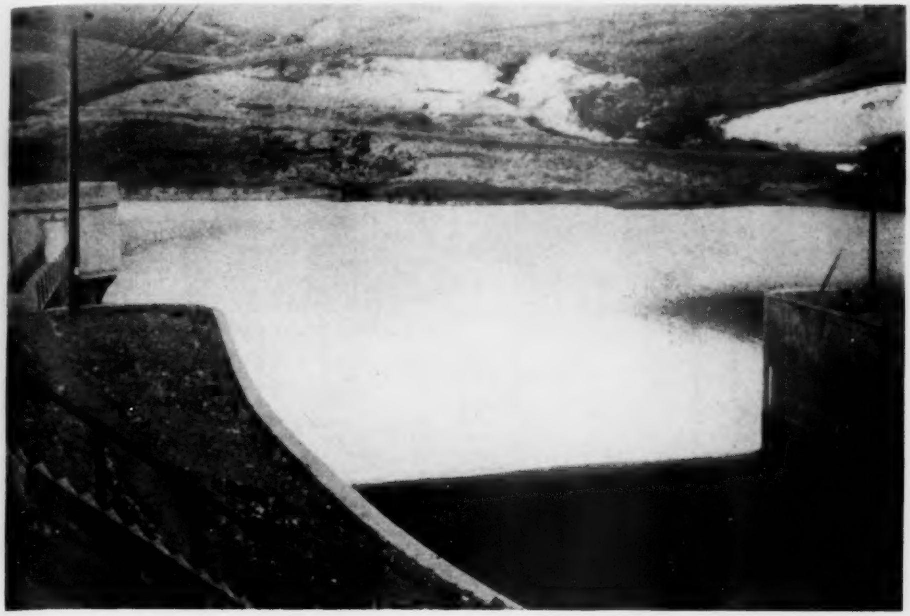

FIG. 9. Spillway and Intake of an Army Post Impounding Reservoir

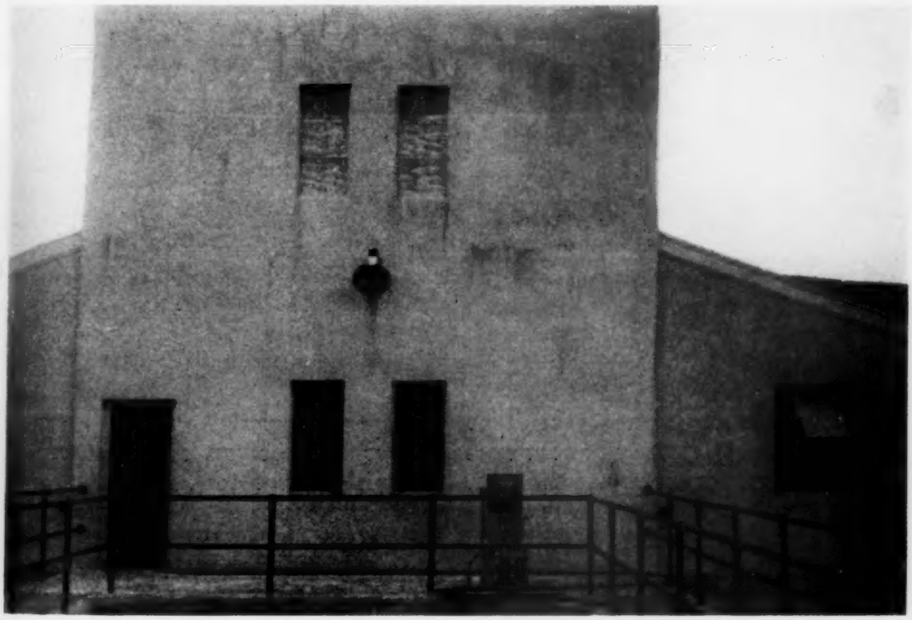

FIG. 10. Chemical Storage and Feeder Building

Fig. 11. Open-Air Operating Gallery and Settling Basin

Fig. 12. A Texas Post Plant With Pneumatic System

Because these supplies offer the only available source of water at these locations, pressures up to 150 psi., temperatures to 120°F., and total solids up to 2200 ppm. are being reduced to produce a usable water.

The Army has typical deep-well pumping installations with electric-driven turbine pump and gasoline-engine drives, and also combination electric- and gasoline-engine-driven horizontal centrifugal pumps. Although some couplings have broken and vibration difficulties have arisen, on the whole, the deep well turbines have given satisfactory performance. Most stations are above ground discharge because of maintenance and sanitary reasons.

Air-lift pumps, found only at posts constructed prior to 1940, are few in number. While the senior author has always been somewhat biased toward this type of deep-well pump, the records show the saturation of the water with oxygen is creating havoc by corrosion in hot water storage tanks. Air lifts are not normally used at new army installations.

One Army post has a Ranney Water Collection System, and several are found at Ordnance plants. The well is located near the bank of the Ohio River with a direct river intake 15 ft. above the bottom of the well. The well itself is 13 ft. in diameter and is 81 ft. in depth below the motor setting, which is 8 ft. above high water. The well collectors or "fingers" are 2 ft. above the bottom of the well and were installed with valves. The well did not produce the guaranteed amount of water at first pumping, but additional construction may increase the capacity. An interesting feature is that the static level is 10 ft. below the normal river water elevation, and chemical analysis of water from each finger varies greatly. About 42 tons of sand per month are pumped and life of pump impellers is short.

Spring Supplies

A number of spring waters are used especially in the West, although in most cases these supplies are augmented with deep wells. It has been found that spring supplies are more or less uncertain and subject to surface contamination.

Operating Personnel and Training

The most important cogs in successful plant performance are the sanitary engineers and plant operators. During 1941 and part of 1942 Engineers in the Water and Sewage Unit, OCE, devoted approximately 25 per cent of their time assisting the Zone Offices, Service Command Headquarters and Civil Service in obtaining qualified personnel for utility work. The assistance of members of the A.W.W.A., engineering firms and universities was solicited with gratifying results. Until the recent reclassification in Selective Service, the turnover in operators has been small. The suggestions in Table 3 are not mandatory, but are a guide for post engineers. In substance, it was first approved by the Office of The Quartermaster General in October 1941. All water and sewage utilities are placed in one of four classifications relative to population bracket and type of plant (Table 4). Obviously additional helpers are needed when two plants exist at a post or when the low-lift station is located at some distance away. The OCE is encouraging a personnel setup at each post whereby a substantial nucleus of men will always be available for water distribution and sewerage collection system maintenance

to the end that the sanitary engineer will not have to procure men from the plumbing section or other post personnel in order to render prompt repair service.

The wisdom of the plan of heading up the water and sewage utilities by sanitary engineers has been revealed more and more as monthly operating reports and reports from the Sanitary Corps Officers indicate better plant operation with fewer complaints or recommendations of the inspecting officers. These high grade men, skilled to some extent in administration as well as operation, are, in general, the

TABLE 3

Table of Allowance of Civilian Personnel for Water Supply and Distribution System at Army Posts

Section	Designation	Class	Base Pay	38,000 and Over		12,000 to 38,000		6,000 to 12,000		1,500 to 6,000	
				No.	Annual Cost	No.	Annual Cost	No.	Annual Cost	No.	Annual Cost
Water and Sewerage Supervision	San. Engr.	P-4	$3800	1	$3800						
	Assoc. San. Engr.	P-3	$3200			1	$3200				
	Asst. San. Engr.	P-2	$2600					1	$2600	1	$2600
Water Pumping & Treatment Plants	*Class A*										
	Work Supervisor	Uncl.	$3000	1	$3000	1	$3000				
	Jr. Chemist	P-1	$2000	1	$2000	1	$2000				
	Sr. Oper. Pumps	Uncl.	$2300	1	$2300	1	$2300				
	Oper. Pumps	Uncl.	$2100	3	$6300	3	$6300				
	Oper. Filters	Uncl.	$2100	4	$8400	4	$8400				
	Class B										
	Works Supervisor	Uncl.	$3000	1	$3000	1	$3000	1	$3000	1	$3000
	Oper. Pumps	Uncl.	$2100	3	$6300	3	$6300	3	$6300	3	$6300
	Class C										
	Works Supervisor	Uncl.	$2800			1	$2800	1	$2800	1	$2800
	Oper. Pumps	Uncl.	$2100			2	$4200	2	$4200	2	$4200
	Class D										
	No operating personnel										
Water Distr. System & Sewerage	Inspector	SP-6	$2000	2*	$4000	1†	$2000				
	Sr. Foreman of Constr. & Maint.	Uncl.	$2000	1*	$2000						
	Foreman of Constr. & Maint.	Uncl.	$1860					1	$1860		
	Jr. Foreman of Constr. & Maint.	Uncl.	$1680	1*	$1680	1†	$1680			1	$1680
	Classified Labor	Uncl.	$1320	3*	$3960	2†	$2460	2	$2460	1	$1320

* 24,000 or over.

† 12,000 to 24,000.

type that can obtain the full co-operation of the Medical Corps, Sanitary Corps and other Service Branch Officers in meeting the problems of plant operation peculiar to the respective posts.

The salary scale of operators and helpers in general compares favorably with that of municipal plants, but in many cases the living conditions have not been particularly inviting. Because of apparent security in municipal employment and the fact that War projects and private industry offered higher salaries, the problem of attracting qualified operators and key men for post utilities work has been difficult. To date, however, about 80 per cent of the civilian personnel employed at Army plants are still employed at their original tasks or have been promoted or transferred to other posts. Immediately after the declaration of War and the second draft, applications by plant operators increased, but it is no longer easy to obtain these men. If some workable plan can be devised to assure over-draft-age non-key operators of municipal plants that, upon acceptance of employment at an Army post, their local Civil Service status will not be impaired, it is believed the water plant operating personnel problem at Army posts can be easily solved. The draft is taking an estimated 30 per cent of Army plant operators. Although Post Engineers have never succeeded in filling all the vacancies created for junior chemists, in general, these positions were filled at the water plants irrespective of shortages which may exist at sewage plants and other laboratories.

Eleven trailer laboratories (Figs. 13 and 14) with trained chemists employed by eight Service Commands are at work. They move to water and sewage plants where serious operating difficulties are encountered. The trailers were purchased by the U.S. Division Engineer Offices from the Coca-Cola Company. The trailers have been used also at twelve short courses for Army plant operators throughout the country.

About 760 men have received special short course training and have been presented with Army Course Certificates, either for water or sewage treatment. The courses are organized and presented by the sanitary engineering section of the Division Offices,

TABLE 4

Classification of Water Works

Type of Water System	Classification for Post or Contributory Population of:			
	38,000 and over	12,000 to 38,000	6,000 to 12,000	1,500 to 6,000
Surface supply, filtration plant	A	A	B	B
Well water supply with iron removal, zeolite softening or complex pumping installations	B	B	C	C
Purchased water with booster pumps or well water supply	B	C	C	C
Purchased water, no booster pumps, no operating personnel	D	D	D	D

Fig. 13. Trailer Laboratory

Fig. 14. Interior of Trailer Laboratory

assisted by Sanitary Corps officers and the local faculty of the universities selected. Assistance has also been obtained from engineers, chemists, members of this association, well known in the field of plant operation and maintenance, and manufacturers' representatives.

Intensive 30-day courses in elements of sanitary engineering and laboratory technique are being completed at New York University, Texas A. & M. College and the University of California. Case School of Applied Science and University of Iowa stand ready to offer two other courses. Graduate engineers, largely civil and over draft age, now employed by the U.S. Engineers or Army posts, are selected to attend these courses. They will become supervisors of sanitary utilities, pest control and waste disposal under the direction of the Post Engineer at some Army Training Center. We are pleased with the 60 men selected and their interest and sincerity of purpose are manifest.

In order to assist the Post Engineer, each Service Command has assigned civilian sanitary engineers or engineer officers, not solely for inspections, but to render service to the engineer officer and plant operators. These engineers also report on required alterations, extensions and betterments and visit water plants at least twice a year, whether or not operating difficulties arise. In accordance with Army regulations, the Medical Corps continuously studies plant operation and recommends improvements where found necessary.

Indications are that the Post Engineer will be entirely dependent upon civilian employees for utility operation. A few chemists in the Headquarters Service Company or Military Police Detachment have been assigned by the Post Commander to water and sewage plant operating problems. Also, in a few instances, non-commissioned officers have been detailed for temporary duty on special problems of utility operation. Other than these, limited service enlisted men are not available to Post Engineers at this writing. It is hoped that Officer allotments can be increased at a number of posts in order that junior officers, qualified in sanitary engineering, can be assigned as Assistant Post Engineers for supervision of utility work.

Two Service Commands have set up thirty-day courses for plant operators at selected posts having complete water and sewage treatment. Men who are high school graduates with a mechanical background and are over draft age are being solicited by Civil Service to enroll in these courses. Salaries are comparable to those of regular operators and post assignments will be made to those who qualify. The first enrollment has been disappointing, but the plan appears feasible, if men can be obtained. A number of women technicians and chemists have been employed at posts but, because their services are somewhat limited, it is hoped the operating staff can be completed with men.

In 1942, the *Repairs and Utilities Manual* was made available to all Post Engineers, craftsmen and utility plant operators. This Manual comprises approximately 1500 pages and was prepared by the OCE as a guide and instruction manual for the operation and maintenance of utilities and other post property. Revisions are made as operating experience indicates the need for supplemental data. A list of current text books and publications is included as a reference for additional

FIG. 15. Trailer Chemical Feeder

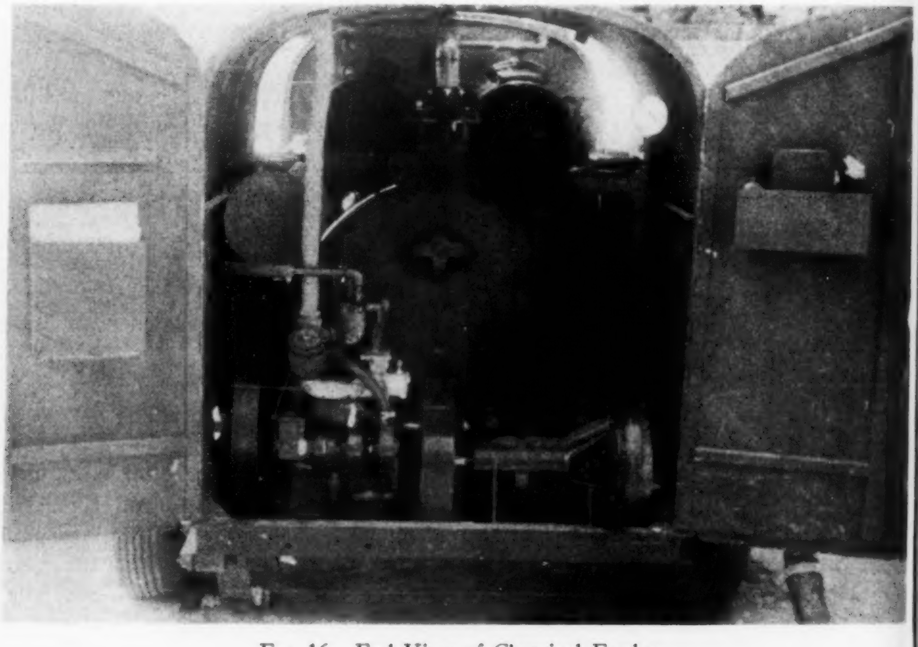

FIG. 16. End View of Chemical Feeder

technical information. Many of these books are provided for the posts by the OCE on requisition.

Operating Problems

Sterilizing Mains

The Area Engineer, directed by the respective U.S. District Engineer Office, and the contractor are charged with the sterilization of water mains, storage tanks, filters and wells, prior to acceptance of the work by the Post Commander. The following minimum dosages of chlorine are used:

Pipe system	50 ppm.	Filters	100 ppm.
Storage tanks	50 ppm.	Wells	150 ppm.

A solution of the treating agent, equivalent to a chlorine concentration of 50,000 ppm., is adopted. Each gallon of the treating solution is made by using the weights of one of the three chemicals shown below:

Liquid chlorine (100 per cent available chlorine)	0.4165 lb.
Chlorinated lime (35 per cent available chlorine)	1.19 lb.
Liquid hypochlorite (10 per cent available chlorine)	4.165 lb.

Because of strict Army time tables, it was often necessary to start activation of some new posts before construction was entirely completed. In some cases, Post Engineers relieved the Area Engineers of final phases of new construction as the troops moved in. Division Offices, therefore, were often faced with many problems, particularly in sterilizing and placing the water system into operation. This was generally accomplished with the use of mobile sterilizing equipment. It was found that trailers designed for liquid chlorine feed did not withstand the rough handling of field use. The McKays Company of St. Paul was requested by the OCE to design a rugged trailer containing chemical feeders suitable for feeding any liquid with the least moving parts possible. The standard design adopted for emergency work is shown in Figs. 15 and 16. Thirty have been purchased by the OCE and delivered to all Division Offices.

The trailers are also used by the Corps of Engineers for treating water systems adjacent to posts where unsafe water has been encountered and they are available for emergency work to assist municipalities. For example, the four trailers of the Fifth Service Command were ready in the recent Ohio River flood to go to any location needing assistance.

Recently at some posts, used piping has been resorted to. At one post the senior author has seen one mile of pipe containing five different kinds of pipe and four different kinds of joints. Refineries and other industries have helped supply used pipe and some private utilities, having non-essential pipe lines, have dug them up and sold pipe to the Army. These lines are difficult to sterilize.

Sterilization has been accomplished by first using a concentration of 100 ppm. of lime in parts of the pipe system for a period of 8 hr. After flushing, the chlorine solution was applied. Indications are that the preliminary procedure has considerable merit. The success of this treatment is apparently due to the action of the caustic on organic matter and grease films in the jute.

Relining Water Mains at Army Posts

Relining water mains with cement has been conducted at a few Army posts and found very satisfactory. In many old Army posts the mains have been corroded to an extent where the capacity has been reduced 70 per cent.

FIG. 17. Pipe Samples Taken From Mains of a Coastal Defense Post

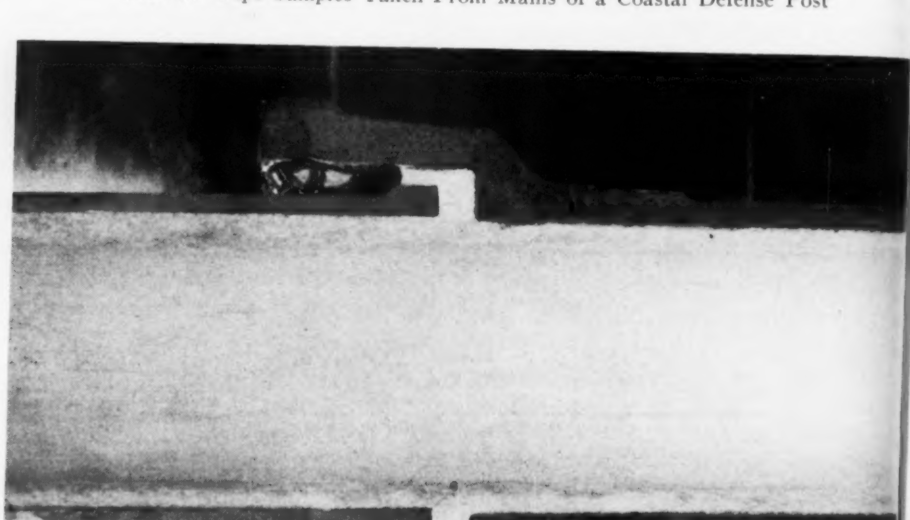

FIG. 18. Relined Pipe

The result has been red water, insufficient fire flow, and inadequate service.

Such pipe has been cleaned and relined by the process used by the Tate Pipe Linings, Inc. Sections of 300–400 ft. at a time were cleaned by the Tate pipe cleaner and relined in place by the lining mandrel. In Fig. 17 are samples of pipe taken from the mains of a coastal defense post where it was found by test that the C factor in the Williams-Hazen pipe line design formula was reduced to as low as 38. Measurements of the roughness factor were made by the Pitometer Co., Engineers, and also by Edmund Couch Jr., Water Waste Engineer, North Atlantic Division Engineer Office (Second Service Command).

The two tests were made on different sections and different lengths of 6-in. relined water mains. The data show the relative improvement due to cleaning and relining. Roughness factors are based on nominal diameters.

Length of Section Tested, ft.	*Before* C	*After* C	*Before* Q, *gpm.*	*After* Q, *gpm.*	*Increase Ratio*
956	38	131	119	410	3.45
2217	±47	114	—	—	2.42

The above C figures are calculated on normal diameters. The work has proven very satisfactory with savings in critical materials, as well as the strengthening of the old pipe. A study of a section cut from relined pipe (Fig. 18) shows how the pipe including joints is reinforced. There was a question as to whether or not the lining would withstand the shock due to firing of large coast defense guns, but to date no leaks have appeared in the relined sections. Post authorities state that, as the relined sections were put into use, all service and red water complaints ceased. Inasmuch as the cost of lining mains by this process averages about one-third the cost of new mains with a minimum of service interruptions, rehabilitation of corroded mains by this process is contemplated at other posts. To this end, surveys are now being promulgated in the Fourth, Eighth and Ninth Service Commands.

Water Waste Survey in Army Posts

In January 1942, the OCE initiated a project known as Water Waste Survey. The purpose of this project was to make leak surveys in all Army posts within the continental United States. The original purpose of the survey was to locate water waste and recommend remedial action.

Practice and experience have enabled the Water Waste Engineer to be of great aid to the post in all phases of water supply maintenance and operation. The scope of service rendered to Post Engineers has far exceeded original expectations.

The equipment used on the surveys is made by Fisher Research Laboratories and Water Leak Detector Co. Both types rely upon sound signals for leak detection. The equipment and the procedure adopted are combined to make rapid and accurate surveys so that a maximum number of posts may be covered with limited time and personnel. The sound equipment picks up vibrations caused by a leak of as small as 3 gpm. at distances from 200 to 400 ft. from a microphone, which is usually clamped to a hydrant nut, valve nut, or sounding rod driven to the crown of the pipe.

The equipment shown in Fig. 19 is that necessary to make an ordinary rough leak survey. Box L is the standard leak detector which is powered by dry cells and may be used from the station wagon or carried by the op-

FIG. 19. Equipment for Ordinary Leak Survey. KEY: *L*—standard leak detector; E_1 & E —pipe energizers; P_t—transmitter; and P_r—receiver

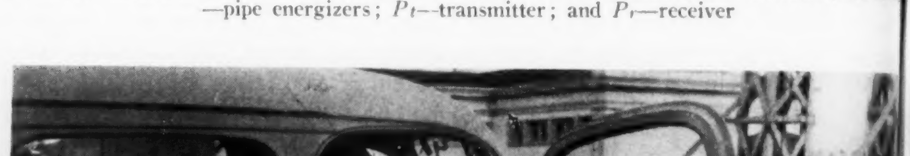

FIG. 20. Use of Leak Detector From Auto in Routine Leak Survey. Official Photo b Signal Corps, U.S. Army

erator. The two boxes E_1 and E_2 contain pipe energizers powered by the "Hot Shot" battery shown in front. Box E_1 is attached to an exposed portion of the pipe and to the ground. Box E_2 with the 500-ft. connecting cable is used to energize any pipe where two points are exposed. The instruments P_T and P_R are the transmitter and receiver respectively of the M-Scope Pipe finder. The handles on the running board (Fig. 19) are used with the M-Scope for pipe, cable or valve exploration.

The use of the leak detector from the car in a routine leak survey is shown in Fig. 20. There are two leak detectors, the DeLuxe powered by a storage battery and used from the car only, and the Standard leak detector shown in Fig. 20 which may be used either from the car or carried by a strap.

Observations on water use, meter records, and judgment of the operator are combined with the listening equipment to give a close examination of the distribution system. It is often possible to "sound" 275 to 300 hydrants and valves in a day, which represents a good sized post water system.

Along with a leak survey, the surveyor checks the post water maps, the location of all parts of the distribution system and locates buried valves and unknown pipe for the purpose of bringing the records up to date. The wells, reservoirs, tanks, filters, pumping stations and any other parts of the system are also checked by the surveyor.

Fire flow tests are run in representative sections of each water system. These serve a dual purpose by checking system capacity, and by locating closed or partially closed valves or other obstructions.

Experience shows that the great majority of leaks and water waste are in seemingly insignificant amounts. Large leaks cause immediate concern and result in emergency calls for the water waste engineer.

The largest reduction in water consumption has been due to the insertion of urinal flush valves to eliminate constant flow. Figure 21 shows water consumption at a southern post before, during and after the installation of urinal flushometer valves in barracks. During May, there occurred a progressive decrease in per capita consumption. The 92.8 gpcd. April requirement was reduced to 73.8 gpcd. in May. At an eastern seaboard post of 14,000 population, per capita consumption was 76.4 gpd. in November, 76.8 gpd. in December and 81.6 gpd. in January. Installation of urinal flush valves reduced water use to 55.6 gpcd. in February, or saved 26.0 gpcd. At the latter post with purchased water at $0.1314 per 1000 gallons, the *monthly* saving averaged $1083.00. The entire flush valve installation and equipment cost $1100 for 200 flushometers. Sanitary Corps officers have reported that urinal conditions are satisfactory and that staining of fixtures is reduced over that observed during original continuous wash down.

Many posts have saved water valued at $350 to $500 per month by eliminating leaks and continuous flow from the perforated flushing bar type urinals. For example, 50 urinals discharging at an average rate of 3 gpm. require 6,480,000 gal. of water per month. Tests at large posts show urinal flush valves reduced total urinal discharge 93 per cent.

The surveyor takes the attitude that all leaks are worthy of location and

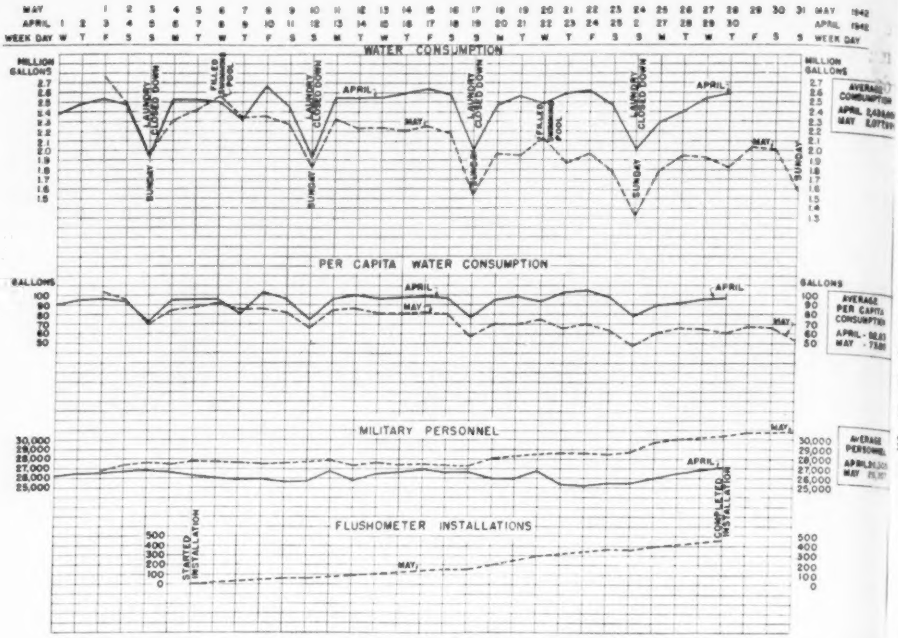

FIG. 21. Water Consumption Before and After Installation of Flushometer Valves

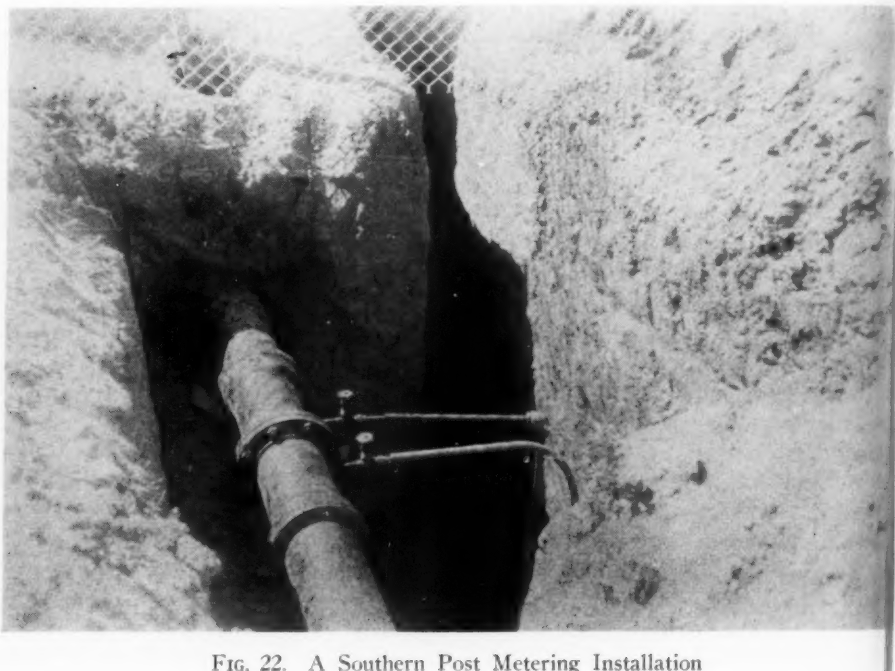

FIG. 22. A Southern Post Metering Installation

correction, even though the small ones may be repaired at some convenient date.

The water waste surveyor's duties automatically make him an inspector of water distribution systems and he does all in his power to help the Post Engineer to run the system efficiently. The work is not an inspection in the usual sense of the word, but is a service to the post and all suggestions, criticisms and recommendations are thoroughly discussed with the personnel directly affected before the report goes to the Division Office.

allotted to measure water requirements of a divisional area with results shown in Fig. 23. Metering a regimental area disclosed the curve shown in Fig. 24. Meters were also provided for a few vehicle wash racks, airplane wash racks, bakeries, hospitals, laundries and officer clubs, but results have not been analyzed except in the case of laundries. The laundry requirement is between 4.8 and 6.3 gal. per pound of clothes. The soldier on the average has laundered daily 1.2 lb. in summer and 0.6 lb. in winter. An attempt is being made to obtain actual data, so that design in-

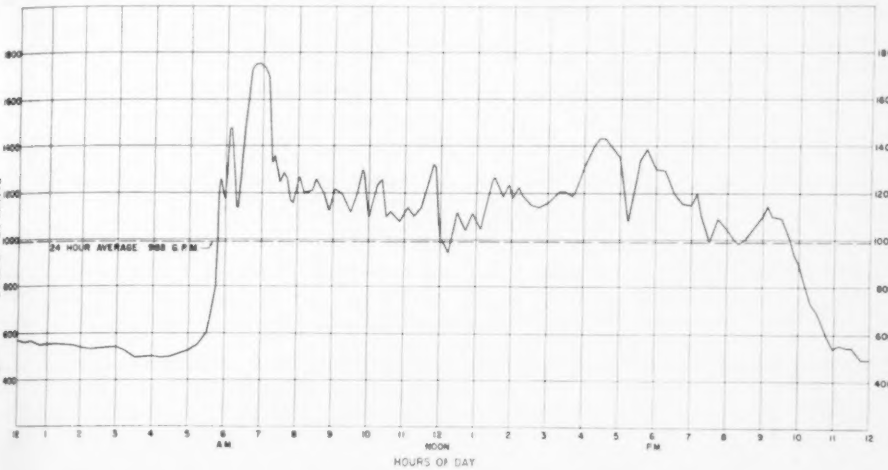

FIG. 23. Variation in Water Consumption for a Typical Divisional Area

Metering of Water

In most of the posts, water meters of the recording venturi, orifice, nozzle, current meter or compound disk and turbine type were installed under new construction to measure the water purchased or produced at the plant. The Repairs and Utilities Branch allotted funds for metering where required. Figure 22 shows a type installed at unit wells in a southern post. At one Service Command, funds were

formation will be available to engineers in case of other national emergencies. Few water or sewage flow records are to be found from World War I experience. Very little trouble has been experienced with metering of water, but such is not the case with sewage. All commercial establishments operating on a profit basis on a post are metered and water is paid for on the basis of not less than the cost of production.

Chlorination of Post Water Supplies

The production and delivery of a safe potable water at all fixed Army installations is the responsibility of the Corps of Engineers. The importance of this task and the ever increasing magnitude of problems of service and protection have demanded constant vigilance, careful planning and resourcefulness. Special apparatus and programs have been initiated which, because of the nature of the problems encountered, are not in many cases adaptable to established municipal practice. These policies have been successful, however, in meeting the problems peculiar to Army installations.

It was found, for instance, that after the activation of the many and various types of water systems constructed throughout the Continental limits of the United States, the 1941 policy for chlorination of these supplies did not afford satisfactory protection under the existing conditions. The policy then in effect called for the installation of chlorinators at all filtration plants or where the supply, either surface or ground water, was of doubtful sanitary quality. Chlorination was not required for properly constructed well supplies or for purchased supplies from established municipal or private utilities.

In the early stages of cantonment and theatre of operation (T.O.) type construction program, the continual development of distribution systems through alterations, extensions and betterments and the dispatch with which this work was accomplished, resulted in non-potable samples far above the number usually disclosed by tests on established municipal systems. There were many causes such as improper main sterilization, cross-connection, improper sampling, and possibly poor technique in bacteriological examination. Classifying water on the basis of plate count where samples were tested after many hours in transit, was also a contributing factor.

Immediate steps were taken to reduce to a minimum, the number of non-potable samples and to safeguard the water supplies against contamination and pollution. It should be recalled that civilians working at posts were not inoculated as is required of all troops. Surveys were initiated at every post for the detection and correction of

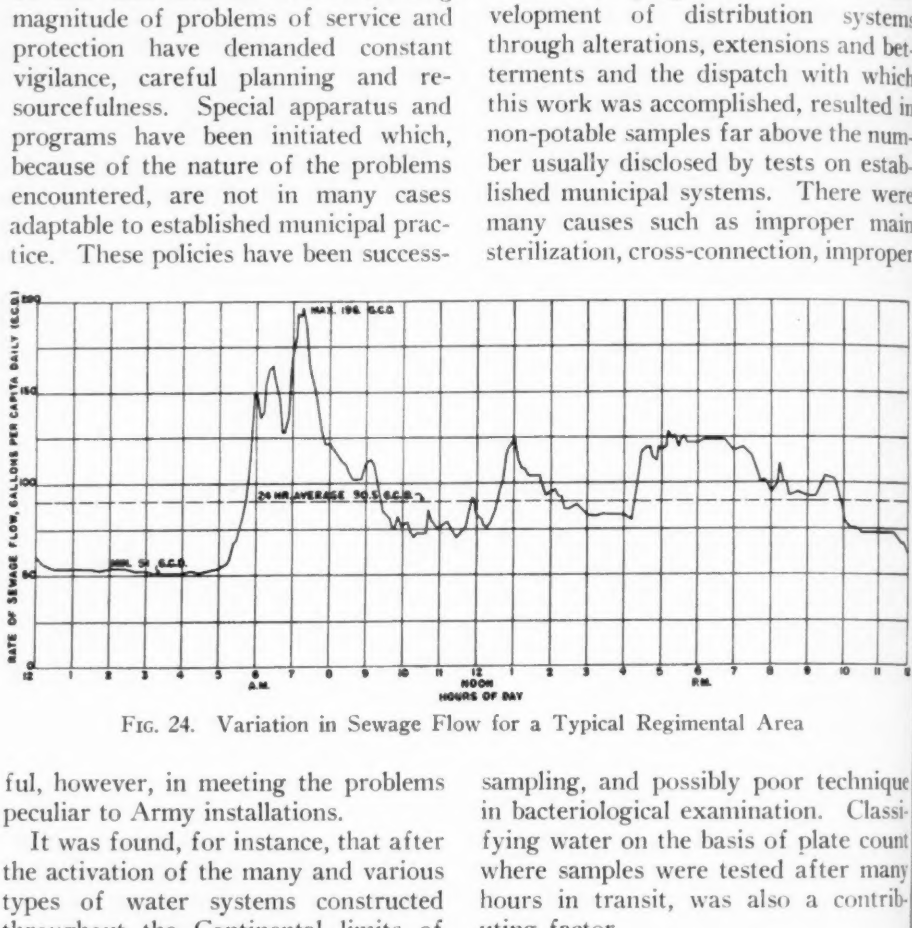

FIG. 24. Variation in Sewage Flow for a Typical Regimental Area

cross-connections resulting from expansion of old established posts and the leasing of private facilities, which in some cases were inadequate as to sanitary design and operation. Approved syphon-breakers were installed on toilet fixtures and dual systems for fire protection were carefully scrutinized.

Analyses reveal that a great number of non-potable samples were found where the water supply was purchased water. Since purchased water usually enters the post distribution system at the far end of the municipal system or through long transmission mains, very little, if any, residual chlorine by the ortho-tolidine test was found to be present in the water as it reached the post. Although the standard Government contract for the purchase of water requires the water to meet U.S. Drinking Water Standards, no requirement is made for furnishing a chlorinated water.

It became evident that, to effect positive protection of all Army supplies against pollution from several sources whether by accident or design, it would be necessary to carry a chlorine residual in all supplies in an amount adequate to meet wartime conditions. The present policy now in effect was drafted by the Office of The Surgeon General, U.S.A., and the Corps of Engineers to assure a measurable amount of free chlorine in the water supply at all times. It provides that at all posts except those installations being served directly and individually by a public water supply distribution system such as leased hotels, depots and repair shops within municipalities (except in special individual cases), a chlorine residual of not less than 0.4 ppm. will be maintained at all times in the active parts of the water distribution system following an additional contact period of not less than 30 min. It has been interpreted that where municipalities supply chlorinated water to Army posts, but with residuals less than required for Army supplies, the requirement for the initial contact period of 30 min. has already been satisfied.

In no case is it the intent of this policy to require municipalities, selling water to government installations, to provide a minimum chlorine residual of 0.4 ppm. at the point of purchase. Figure 25 shows the percentage decrease in the non-potable samples of the Service Command reporting the greatest number of samples. It is anticipated that when full compliance of the policy is realized and all new chlorinator installations occasioned by this policy are completed, the result may equal that of a smaller Service Command, which in April 1943 reported no non-potable samples.

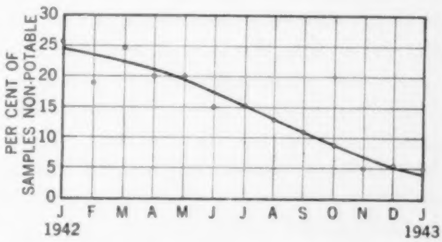

Fig. 25. Decrease in Non-Potable Samples in Service Command With Largest Number of Samples

Except at posts now under construction, all the additional chlorinators required for compliance with the policy were purchased centrally and distributed to the respective Service Commands. Every standard make of chlorinator and hypochlorinator has been purchased on negotiated contracts in order to expedite the program. Al-

though some of the installed chlorinating equipment did not have sufficient capacity to maintain the higher residuals called for by the present policy, none have been discarded. In such cases, small capacity machines have been reinstalled at smaller posts and replaced with equipment of adequate capacity.

It is anticipated that at a number of stations the 0.4 ppm. residual cannot be considered mandatory where the presence of iron, manganese or other chlorine-consuming properties of the water make this residual impractical or where water is stored for long periods in large mains or reservoirs following chlorination. Very little "relay" chlorination is contemplated. In the event that the presence of mineral or organic compounds makes it impossible to produce a water of acceptable quality, treatment for the removal of such compounds will be required. Ammonia in conjunction with chlorine may be used at the larger posts where chlorine tastes are deemed to be very objectionable. About twenty posts are using chloramine treatment. The use of P-Aminodimethylaniline as an indicator for free chlorine, described by W. A. Moore of the U.S.P.H.S. Division of Public Health Methods (Jour. A.W.W.A., **35**: 427 (1943)), will be instituted very shortly to observe results on free chlorine being carried at Army posts.

Where automatic hypochlorinators are being installed at small posts or sub-posts, a minimum orifice differential pressure of 2 in. of water through the small water meter is being used. A ratio of minimum to maximum flow of from 1 to 8 is planned. In a number of locations, time clocks may be installed to operate automatic hypochlorinators periodically at the very low night flow periods.

Chlorine Cylinders

The often reported shortage of chlorine for sanitary purposes was largely a shortage in containers only. Therefore, in 1941, the Office of The Quartermaster General initiated a program for the centralized purchase and use of 7000 150-lb. light-weight type of chlorine cylinders with Chlorine Institute approved valves. This departure from usual practice was carried out after work was transferred to the Corps of Engineers and the order has been increased several times. Liquid chlorine for Army use is now purchased in Army-owned cylinders under contract from several manufacturers and jobbers f.o.b. works at a cost range of 3.2 to 5.4 cents per pound. Land grant freight rates available to the government contribute to the low delivered cost. The liquid chlorine requirements for sanitary purposes including sewage treatment are about 2000 tons a year. In general, posts above 2500 population use liquid chlorine; sodium hypochlorite is used for water supplies at smaller installations. Since December 1941, the use of calcium hypochlorite (70 per cent available chlorine), except from old CCC stocks, has been limited to locations where sodium hypochlorite solution is not available.

Protective Measures Against Enemy Action

Down through the history of warfare, an Army's water supply has been an important factor in military operation and in many cases has been subject to sabotage and direct enemy action. It has been assumed, therefore, that

the water supply serving a large concentration of military personnel would offer a dramatic target for the saboteur.

Perhaps the most effective means of protection of any water supply and that employed at all Army installations, is constant vigilance and adequate guard facilities. In addition to restricting areas, fencing, lighting, guard patrols and strict supervision of plants and operation, the Army conducts routine tests to assure the safety and potability of Army controlled water supplies. Under the present program, the addition of toxic chemicals or other harmful agents can be immediately detected.

In those areas forming a coastal belt, special consideration has been given to the maintenance of additional fire protection in critical post areas. This is accomplished by means of auxiliary ground storage reservoirs for use in case of failure of the post water supply due to enemy action. In general, the reservoirs are of simple construction in the form of wood or concrete tanks and of about 20,000-gal. capacity. They are installed within easy access of fire pumpers and are entirely independent of the water distribution system.

Scale and Corrosion

One of the major problems of water supply now confronting the Corps of Engineers and one which is in some respects more critical in Army water supplies than in the industry at large, is the problem of scale and corrosion. The critical factor peculiar to Army water supplies is the necessity for maintaining the high temperature of 180°F. in the mess hall hot water systems for the sterilization of dishes and equipment.

Scale or corrosion, or both, accelerated by these high temperatures, are causing the failure of hot water heaters, storage tanks and plumbing systems at many posts throughout the country.

Because of the alarming rate of failures, the critical shortage of replacement equipment and the many localities and types of waters involved, the OCE has recognized and accepted this problem as one of first priority.

The necessity for using lighter gage metals, with the exclusion of a corrosion factor, in the manufacture of hot water storage tanks has accelerated the promotion and dispatch of this study.

The first step in control was a request for complete chemical analyses of all potable water supplies from established camps, posts and stations, as well as all new installations. It was found that the chemical constituents of these water supplies varied in a range from "nothing waters" (those having practically no dissolved solids) to those typical of sea water. To obtain a comprehensive picture of the problem, the chemical analyses as submitted by the field are transferred to a standard work sheet, OCE Form No. 830 (Fig. 26). A short description of some of the main features of this form is of interest because it is now used as a basis for the classification of water into categories for proper treatment. The form was designed to:

1. Standardize the form of recording the chemical analysis.
2. Provide a means for checking the accuracy of the analysis as submitted by the field.
3. Provide the means of showing graphically the probable manner in which the chemical constituents will combine.
4. Provide means of determining the

OCE Form No. 830

S.C. 6 Post

Type AAF Location WISCONSIN

WAR DEPARTMENT
OCE, Const. Div., R&U Br., M & U Sect.,
Water, Sewer & Services Unit

Analysis		P.P.M.	pH 7.62		
Total Alkalinity		296	Date		
Total Dissolved Solids		322	Mg. Equiv. per Kg.		P.P.M. Solids
Total Hardness		270			
Hydrogen Sulphide	(H_2S)	-			
Carbon Dioxide	(CO_2)	30			
Dissolved Oxygen	(O)	4.6			
Manganese	(Mn)	-			
Iron	(Fe)	.4			
Silica	(SiO_2)	7.0			7
Flourine	(F)	-			
Calcium	(Ca)	61.8	3.08		62
Magnesium	(Mg)	27.7	2.29		28
Sodium	(Na)	31.	1.36		31
Potassium	(K)				
			6.73		
Bicarbonate	(HCO_3)				
Carbonate	(CO_3)				
Sulphate	(SO_4)	27.0		.56	27
Chloride	(Cl)	9.0		.25	9
Nitrate	(NO_3)				
TOTAL ALKALINITY (M.O.L.)		296		5.92	178
				6.73	342

Langelier	pH_s	Index	
20°C.	7.40	.22	▨ - Ca ▩ - $HCO_3 + CO_3$; ▨ - Mg ▩ - SO_4; □ - Na+K ▩ - Cl
40°C.	7.05	.57	C.H. / N.C.H.
90°C.	6.30	1.42	P. Alk. / M.O. Alk.

Remarks:
Scale at all temperatures 20° to 90° C

Category	Treatment
2A	Treat to control scale formation with either the phosphate or the organic scale inhibitors.

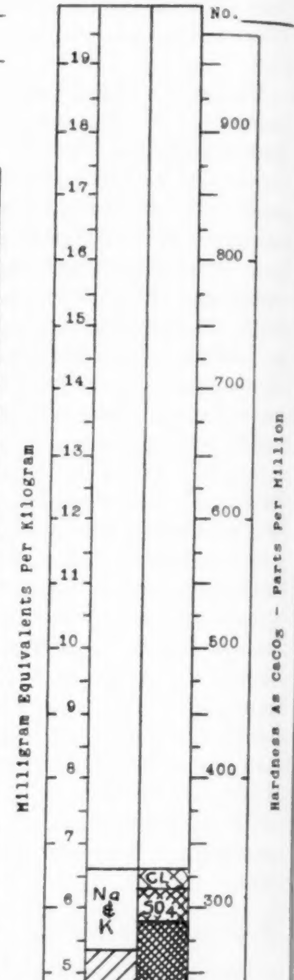

FIG. 26. Standard Work Sheet, OCE Form No. 830

water characteristics and the scale and corrosion behavior likely to be experienced under post operating conditions.

5. Provide sufficient information for classifying the water into categories for proper treatment.

The water analysis as reported by the field in parts per million is recorded in the first two columns on this form. It will be noted that the acids and the bases are recorded as radicals. The next two columns are used for balancing the positive and negative radicals. The equivalent per million (epm.) system as used by W. D. Collins of the U.S.G.S. Division of Quality of Water was adopted. By this method, it is possible to check the accuracy of the analyses and to compute missing elements. In column 5, total solids in parts per million are computed as a check on field analysis and are used in the computation of Langelier's Index of calcium carbonate saturation. By plotting the equivalent per million gram value of the acids and bases in their proper order on the vertical scale provided on the right, it is possible to show graphically the composition of natural or treated water. Simple multiplication of the values by the proper combining factors permits conversion of the hypothetical combining values into parts per million compounds.

The second step in control is the placing of waters into categories for the purpose of recommending treatment for scale and corrosion.

The category classification, in order to be workable, had to be simple. The calcium content as Ca and Langelier's Index of saturation are adopted as the basis of classification. To compute the Langelier Index, there are used a graph and nomogram based on the article "The Analytical Control of Anti-Corrosion Water Treatment" by W. F. Langelier (Jour. A.W.W.A., **28**: 1500 (1936)) and on later corrections for Tables 2 and 4 of that paper (*see* Jour. A.W.W.A., **30**: 1802 (1938)), prepared for C. P. Hoover by Merrill L. Riehl, now with the Ohio River Division Engineer Office. (See also p. 251 et seq. of the A.W.W.A. *Manual of Water Quality and Treatment.*) Waters are divided into five categories, namely: 1, 1a, 2, 2a, and 3, as shown in Table 5.

In addition to denoting classification, Table 5 describes recommended treatments as arrived at by careful study and field investigation. It will be noted that the term "threshold conditioning" is used. Hereafter, threshold conditioning refers to any chemical treatment of water with small concentrations (below about 25 ppm. bulk chemical) of non-toxic chemicals, either mineral, organic or both, which are introduced or dosed into the potable water supply for the prevention or control of scale formation, corrosion, or both.

Category 1

All waters shown in Category 1, have a calcium content of less than 25 ppm. as Ca. It is known that a low calcium content cannot, under any normal circumstances, cause serious scale. Waters in this category are generally high in CO_2 and low in pH. Langelier's Index is usually negative, indicating a potentially aggressive condition. Waters in this group are usually corrosive, if dissolved oxygen is present. The low calcium content would indicate that no protective coating could be expected from the calcium content. Recommended treatments for waters in this category are such as to build up or deposit a coating or film on the metallic surfaces. The general treatment is to

neutralize all aggressive CO_2 with lime by continuing the conditioning of water until a slight color is obtained with phenolphthalein. If the water is still corrosive after the pH adjustment, additional conditioning with sodium silicate may be necessary. The calcium content as Ca is always kept below 25 ppm. Because of directives which cannot be disclosed here, the pH of water at Army installations is not adjusted above 8.5. Cement lined hot water storage tanks are recommended for all new installations in this category.

Category 1a

All waters with a calcium content over 25 ppm. and under 50 ppm. are included in Category 1a. Waters in this group cannot be considered heavy scale forming waters, but many have sufficient calcium to cause scale forma-

TABLE 5

General Category of Waters at U.S. Army Camps and Posts and Threshold Conditioning Recommended for Scale and Corrosion Control of Potable Waters

(War Department, O.C.E., Construction Division, Repairs & Utilities Branch, Utilities Section, Water and Sewage Unit)

Category	Calcium as Ca in ppm.	General Description	Conditioning, when necessary—considering cost, no. of points of application and critical materials involved
1	0 to 25	Normal soft water free from high concentrations of residual iron and manganese and non-scaling. Corrosive, if dissolved oxygen is present.	Use cement lined hot water storage tanks. Stabilize with lime or other caustic—pH not to exceed 8.5 and Calcium as Ca in finished water not to exceed 25 ppm. Lime only, silicate only, silicate plus caustic or other conditioning chemicals, if necessary.
1a	26 to 50	Medium soft waters free from high concentrations of residual iron and manganese. May cause scale trouble.	Cement lined tanks may be used. Stabilize with soda ash, caustic soda, sodium silicate or alkali plus silicate or other threshold conditioning, if necessary.
2	Over 50	Langelier's Saturation Index changes from negative to positive in the temp. range of 20° to 90°C.	Many waters in this group need only slight pH adjustment. In general adjust pH to Langelier's pH_s at critical temperature. Threshold conditioning with organic or polyphosphate compounds may be necessary.
2a	Over 50	Langelier's Index always positive.	Threshold conditioning to control scale formation. Adjust the treatment to retain a slight scale in the hot water tank.
3	Hardness excessive; special or difficult waters	All waters not falling in Categories 1 to 2a incl.	Softening: Zeolite (partial or total), soda-ash. Special treatment such as is required for the removal of iron, manganese, H_2S, color, turbidity, odor, etc.

NOTE: Exceptionally hard waters and waters requiring special treatment because of objectional chemical content regardless of the calcium content will automatically be placed in Category 3.

DATE: June 1, 1943.

tion in some instances. Here, calcium cannot be depended on to lay lown a protective calcium carbonate coating. Generally Langelier's pH of saturation will show a negative index and, if oxygen is present, this water will be corrosive. Cement lined hot water storage tanks should be used in many cases, especially on the low calcium content water. Soda ash or some alkali other than lime is recommended for pH adjustment. The CO_2 is neutralized to a point where slight color is noted with phenolphthalein. If still corrosive, after pH adjustment, addition of sodium silicate is recommended. Threshold conditioning with either the phosphate or the organic compounds may be necessary.

Category 2

Category 2 includes waters with a calcium content as Ca of 50 ppm. or higher and in which the Langelier's Index of calcium carbonate saturation changes from negative to positive within the temperature range from 20° to 90°C. Waters in this group are classed as scale forming waters and scale trouble is anticipated. Threshold conditioning is recommended with phosphate or organic scale inhibitors so adjusted as to leave a slight protective calcium carbonate coating on the metal surfaces.

Category 2a

Category 2a includes waters with a calcium content over 50 ppm. as Ca in which the Langelier's Index is always positive. Waters in this group are classed as heavy scale depositing waters and invariably cause the clogging of heaters and hot water coils with scale.

Either phosphate or organic compounds are recommended for the treatment of water in this category to inhibit scale formation with the conditioning so controlled as to retain a slightly protective calcium carbonate coating on all metal surfaces to inhibit corrosion. Care should be taken to prevent the formation of a phosphate after-scale by over treatment. Flaking and accumulation of this phosphate scale has clogged heaters.

Category 3

In Category 3 are classified all waters that require special treatment as well as those waters that cannot be relied upon to respond to economical threshold conditioning. Waters that require the new construction of filter plants, iron and manganese removal units, zeolite or other softening methods, and aeration etc., are placed here. Problems arising within this category are referred to the Engineering Branch, OCE, as new construction projects.

After the proper classification of waters into the above categories and the correct application of threshold conditioning, most of the scale and corrosion difficulties can be controlled together with the stabilization of calcium carbonate, dissolved iron and manganese within reasonable limits. Successful control will not only result in a tremendous saving of critical materials and labor, but will effect continuity of service essential to the Army Training Program.

Discussion of the Scale and Corrosion Study

Inasmuch as it is believed that for the first time in the history of water production, 751 accurate chemical water analyses, together with field observations from all sections of the country, are undergoing study in one office, the successful classification of waters into categories is manifest. Table 6 shows

the classification of the waters within the nine Service Commands all in accord with categories in Table 5. The objective of categorical arrangement is to simplify and expedite recommendations to the field for threshold conditioning. It is recognized that many authorities have discouraged such a procedure as being impossible. There is a sign in the office that states "The difficult we do today, the impossible takes a little longer." We think perhaps that sign caused encouragement.

The categories as set up have been studied since December 1942. Field rather than being limited to a local experience here and there, as is commonly disclosed in the technical press, it is believed that the behavior of certain waters can be predicted and proper corrective treatment recommended to inhibit scale and control corrosion in most cases. It is not expected that successful treatment will be obtained at all posts on first recommendations.

Included in the scale and corrosion study was a review of many available articles, papers and experiences of municipal plants and a considerable number of industrial problems of non-

TABLE 6

Classification of 751 Water Analyses with Respect to Categories

Category	Service Commands										
	1	2	3	4	5	6	7	8	9	Total	%
1	30	42	35	91	11	15	16	48	81	369	49.2
1a	8	14	14	23	22	23	13	36	56	209	27.8
2	0	1	3	13	6	8	16	22	30	99	13.2
2a	0	2	2	3	13	11	7	21	11	70	9.3
3	0	0	0	0	0	0	2	0	2	4	.5
Total	38	59	54	130	52	57	54	127	180	751	100.0

surveys of threshold conditioning at posts have been conducted using phosphates, silicates and organic compounds. Full scale tests were conducted at 12 posts using the various molecular dehydrated phosphates. These chemicals were used on typical waters to verify the recommendations disclosed herein. Table 7 shows the classification of 794 waters of the Service Commands on the basis of hardness. The remainder of the 1044 waters, it is believed, will not materially change the percentage value.

Because of the fact that the OCE has had available an overall picture recirculated water. These studies also materially assisted in formulating the general recommendations for treatment in the field. The overall picture disclosed that often red water troubles were none other than the precipitation of dissolved iron in the presence of dissolved oxygen rather than severe corrosion as reported by the field. Many instances cited in the technical press where a certain chemical is claimed to have prevented corrosion actually must have prevented iron deposition.

It was concluded that certain companies made claims beyond the range

of capability of their compound and really neglected the field in which their product was effective.

It was also found that in many instances the use of inhibitors has made it possible to postpone the construction of iron removal or aeration plants and by so doing large amounts of critical material and labor have been saved. One Army post, we are positive, would be better off, if no iron removal plant had been constructed because the treatment causes severe corrosion by increasing the dissolved oxygen concentration of a well water that was essentially free of oxygen before the plant was constructed. Threshold conditioning would have held the iron in solution. The OCE caused the rejection of an iron removal plant at one of the largest posts, with a resultant saving of about $500,000. Threshold conditioning of the water has proven successful at this installation. Although the limits of threshold treatment with respect to iron control have not been determined, the Army has successfully treated water containing up to 3.0 ppm. of dissolved iron by this method.

We do not know the limits at which scale will fail to be prevented by threshold conditioning but waters with a hardness of 307 ppm. and an alkalinity of approximately 200 ppm. at temperatures approaching 180°F. have been successfully treated at Army installations. Indications are that manganese can also be controlled within certain reasonable limits.

TABLE 7

Classification of 794 Water Analyses With Respect to Hardness as Calcium Carbonate

Hardness in ppm.	Service Commands										
	1	2	3	4	5	6	7	8	9	Total	%
0 to 10	2	6	4	16	0	2	1	12	5	48	6.0−
11 to 25	20	17	8	25	1	0	4	12	15	102	12.9−
26 to 49	7	10	13	30	3	3	6	17	25	114	14.4−
50 to 99	18	11	30	28	11	9	11	17	32	167	21.0−
100	7	16	9	24	22	14	18	32	57	199	25.2−
200	0	2	2	5	9	8	12	17	32	87	10.9
300	0	0	0	0	11	3	11	15	13	53	6.7
400	0	0	0	0	0	1	1	2	2	6	.8−
500	0	0	0	1	1	0	0	4	4	10	1.2
600	0	1	0	1	0	0	2	0	0	4	.5
700	0	0	0	0	0	0	0	1	0	1	.1
800	0	1	0	0	0	0	0	0	0	1	.1
900	0	0	0	0	0	0	1	0	0	1	.1
1000	0	0	0	0	0	0	1	0	0	1	.1
Total	54	64	66	130	58	40	68	129	185	794	100.0

The solution of the immediate problem of corrosion is based on protective coatings or chemical films which may be applied to the exposed metal surfaces. For instance, on the very low calcium waters the Army depends on cement lining of hot water storage tanks. Aggressive CO_2 is neutralized with lime to a pH of 8.3 and those

waters that are still corrosive are then treated with sodium silicate to furnish the protective coating or film.

In Category 1a, less emphasis is given to cement lined tanks and more to silicate treatment. Because the calcium content is already sufficiently high, soda ash or an alkali other than lime is recommended for neutralization of the CO_2. In Categories 2 and 2a, it is the aim to adjust the treatment to leave a slight calcium carbonate deposit on all metallic surfaces affected. Some posts use intermittent treatment, with test nipples above the heaters as an observation and control station. Intermittent treatment has been very successful in waters from the Edwards limestone in Texas. This water is very high in bicarbonates and alkalinity.

Some of the organic compounds and some of the mixed inorganic compounds show ability to lay down a protective coating in waters up to 200°F.

Present observations indicate that chlorination of water up to a point where free chlorine is always present, does affect the efficiency of the organic compounds, but does not materially affect the inorganic compounds. This is quite important because of the existing chlorination policy at all Army posts. This does not mean, however, that the Army will abandon the use of organic compounds because there are installations where it is impractical, if not impossible, to maintain high chlorine residuals throughout the system. In certain municipalities, the use of organic compounds might be more desirable from the standpoint of the end use of the water.

It has been observed that certain natural surface waters contain some type of organic corrosion inhibitor which causes the deposit of a protective slime, while well waters of similar chemical constituents which have no like substances present are extremely corrosive.

Comparative Tests on Threshold Conditioning

During the progress of the water treatment investigation previously described, and in order to make comparative tests of the organic and inorganic inhibitors with respect to their effectiveness and cost, it was necessary to set up a test station at some post at which the better known inhibitors could be tried out under controlled conditions. A Wisconsin station was used having water analysis as shown in Fig. 26. Tests were conducted under the supervision of the Sixth Service Command with full time sanitary engineer and chemist in charge. Eight different manufacturers were invited to participate in this experiment after a careful check was conducted to eliminate all but those chemicals that will not affect the potability of the water supply.

The tests were conducted in the following manner:

1. Each manufacturer was assigned one 2000-man mess hall and one 100-man latrine in which to assemble feeding equipment and chemicals. Each manufacturer was allowed to determine the extent of the conditioning or the amount of compound required to treat best the water at that post for scale and corrosion control at temperatures of 180°F. or above.

2. Twelve 10-in. long nipples of new black iron pipe with reamed ends were installed in each latrine. Six were inserted on the hot water line leading from the Thrush heater to the hot water storage tank and six in the hot water line on the discharge end of the storage tank. Clean sand-blasted plates of soft steel were suspended in the tank

from the top in the upper one fourth of the tank. The cord holding the plates acted as an insulator. The object of this part of the test was to observe the depth of pitting due to the aggressiveness of the hot water. One test station used untreated water. Steel generating coils, required due to shortage of copper for this service, fail in this hot water in about sixty days.

through all 16-hr. days, using average temperatures for night readings.

c. Hourly records of the high, low and average temperatures were recorded on a master sheet, together with the total amount of water used per day.

d. At the end of 30-day periods, averages and totals of the various daily records were made, and one of the test nipples was cut in quarters, one

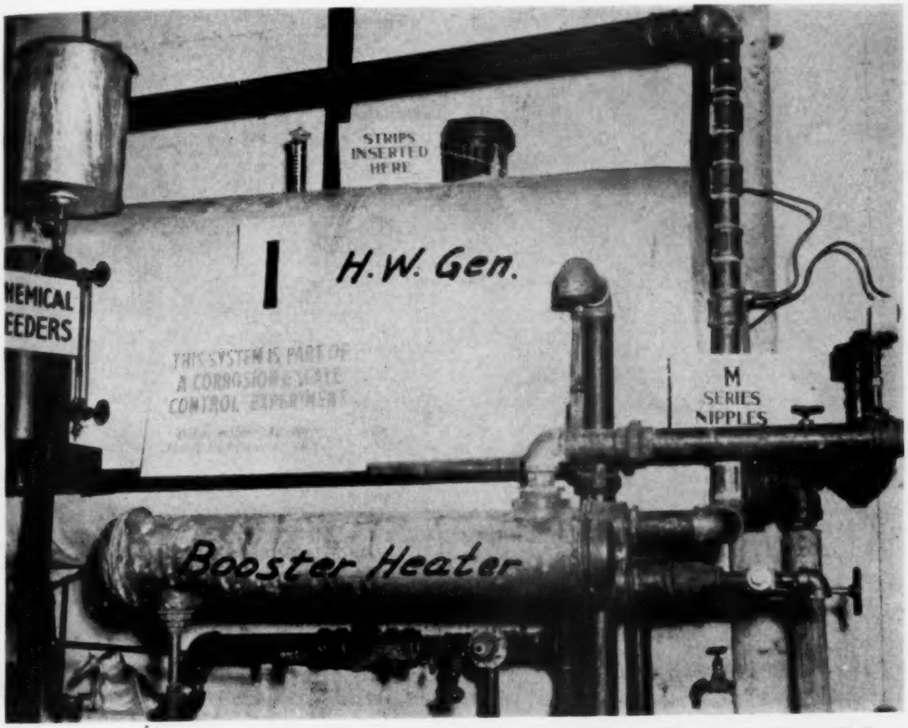

FIG. 27. Nipples Installed in Hot-Water Discharge Pipe From Heaters in Mess Halls

3. A set of nipples was installed in the discharge pipe leading from the hot water heaters in the mess halls (Fig. 27).

4. The following observations were made:

a. Hourly records of the hot water temperature in the storage tanks, the quantity of the water by meter reading.

b. Hourly readings were taken

quarter to remain at the post, one for file in the office of the Sixth Service Command, one for the files of the OCE in Washington, and the other submitted to the manufacturer for his information.

e. Steel plates were removed, examined and photographed. They were then cleaned and the extent of the corrosion determined. The general condi-

tion of each heating unit was studied and records were made and submitted to the several offices. In this manner a complete record of the experiment was kept.

5. In conjunction with the test of the products of the eight manufacturers qualifying for this experiment, the Sixth Service Command found it desirable to conduct experiments on the studies on effectiveness of sacrificial metals as a control of corrosion. The studies at the University of Wisconsin are also being conducted under the supervision of the Sixth Service Command at the request of the OCE.

The results of the tests at this post showed that at least three of the eight inhibitors could be used to control scale formation, for this particular water.

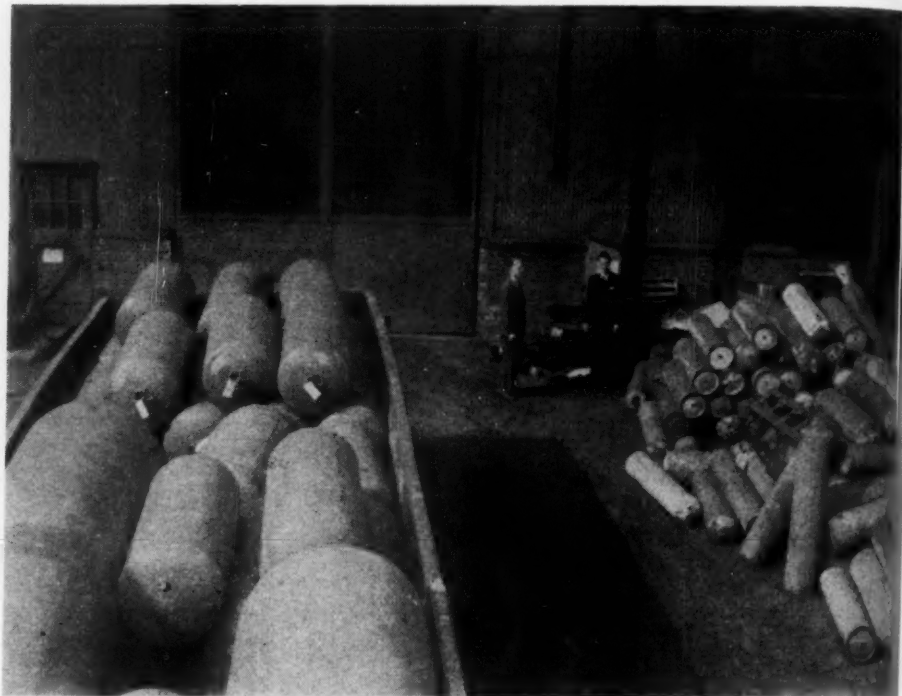

FIG. 28. A Shipment of Hot-Water Tanks From One Post

effectiveness of temperature control and combinations of various inhibitors.

6. In order for the OCE to obtain information on the effect of temperature and pressure on pH in hot water boilers, independent studies were conducted at the Hydraulic Laboratory of the University of Wisconsin. The studies to date have not been completed and will be continued, together with the

The test plates and the nipples revealed that at least two of the compounds gave reasonable protection against corrosion by laying down a protective coating. One of the deciding factors in making the decision as to which compound was to be used at this post was the cost of treatment. The costs varied over a wide range of from 1 to 10.

Cement Lined Hot Water Storage Tanks

During scale and corrosion tests, the OCE conducted tests at Ft. George G. Meade on a thin wall (12-gage) tank lined with a special hydraulic cement lining material known as "Zemanoc." The tank was stressed at 85 psi. and each hour the water was heated to 200°F. One hundred such cycles disclosed no failure in the cement lining. Actual service during four additional months indicates the feasibility of this type of protection. Figure 28 shows

TABLE 8

Unit Costs and Budget Estimates

	Water Mains, per Mile		Pumping Stations, per 1000 gpd. capac.		Filtration Plants, per 1000 gpd. capac.	
	Normal Maintenance	Alterations and Additions	Normal Maintenance	Alterations and Additions	Normal Maintenance	Alterations and Additions
Maintenance*						
Avg. Municipal Cost	$125	—	—	—	$0.671	—
Preliminary Estimate	150	300	$0.30	$0.60	0.985	$2.00
Cost From Survey at 20 Posts of 737 mi.	227	133	.343	.463	0.401	0.438
Final Budget Estimate 1943	180	180	0.40	0.40	0.70	0.70
Total Estimate	$360		$0.80		$1.40	
Labor	$127	—	$0.45	—	$0.224	$0.43
Material	100	—	0.98	—	0.177	
Total Maintenance	227	133	0.343	0.463	0.401	0.438
Total Units Reported in Survey	737 mi.		124,250,000 gpd.		18,250,000 gpd. (4 plants)	
Operating Supplies*						
Average From Survey of 20 Posts	—	—	$0.10		$3.11	
Budget Estimate	—	—	0.10		3.10	
Operating Labor and Supplies—1944 Budget						
Requested	$542	$648†	$3.28		$ 6.93	
Allowed	238	327†	2.13		10.00	

Avg. Cost of Purchased Water = $0.102 per 1000 gal. in 1942
Avg. Cost of Purchased Water = 0.10 per 1000 gal. allowed in 1943
Avg. Cost of Purchased Water = 0.11 per 1000 gal. allowed in 1944

* Figures do not include either operating labor or power costs.
† Figures are for water services per mile.

the shipment of tanks from one post before and after reconditioning in the cement lining plant. A number of posts will adopt lining of tanks in place, where manholes are available. After the tank is properly cleaned, the lining material is mixed with water to form a dense lining (of the consistency of putty) which is troweled over the interior surface of the tank to a minimum thickness of $\frac{3}{8}$ in. The tanks in Fig. 28 had been scrapped because of failure due to corrosion, and were considered a total loss after six months' operation. The loss at another post in six months would have required more tonnage of steel than the saving made by non-manufacture of auto license plates for the State of New York. This gives some idea of the magnitude and importance of the corrosion problem at many posts relative to the saving of critical material, labor and transportation.

Operating Costs and Estimates

The Water and Sewage Unit of the Repairs and Utilities Branch is charged with the preparation of budget estimates for all maintenance, repair and plant operation. In the preparation of the first fiscal budget estimate, questionnaires as to supporting data were sent to 75 representative cities of population comparable to that of Army posts. The response was most gratifying. Many A.W.W.A. members assisted in these reports and will be interested to know that although subsequent adjustments were found to be necessary, the original budget based on these reports was successfully defended and that adequate funds were provided for proper operation and maintenance purposes.

In February 1942, twenty representative posts were selected for study as to maintenance, repair and operating costs. An analysis of these costs, as well as the estimate for the 1943 fiscal year, may be found in Table 8. The 1944 estimate is based on more complete information, and a new cost accounting system, separating recurring and non-recurring maintenance items, will provide data for more accurate estimates in the future. The lack of available data for budgeting operating and maintenance costs has been apparent, and it is hoped that more such data will appear in the technical press.

Summary

It is assumed that this paper will acquaint the profession at large with some of the problems and practices associated with the development and operation of Army water supplies. Many of these same problems are common to public supplies. Certainly, the exchange of ideas and practices is necessary in the interests of the profession and to serve best our country at war.

We believe that the Army has used to best advantage the progressive developments advanced by water works men throughout the country. The continued interest and vigilance displayed by members of *this* Association for the further advancement of water works engineering is manifest and is most essential.

Postwar Water Works Materials

By W. Victor Weir

THE availability of new materials for postwar use in the water works field is of primary concern to almost all of us—managers, operators, water works engineers, consulting and designing engineers and manufacturers and suppliers of water works materials and equipment. Eventually we will all have to undertake the task of reconverting the water supply industry from its wartime status to normal peacetime activity. Materials and manpower shortages will one day disappear with startling suddenness and our problem will no longer be to see what we can eliminate or defer. With the end of the war we will have to take care of deferred maintenance, we will have to replace obsolete or worn-out equipment, we will have to increase plant and distribution system capacity to provide the proper factor of safety to take care of all water demands at all times.

Victory will bring another responsibility. We will have won the privilege of continuing to settle the nation's problems by democratic methods, and first of these problems will be that of weathering the temporary slack period that will result when war industry "lays off" its employees to reconvert to peacetime production and when the armed services disgorge millions of men. During that period, we of the water works industry, together with every other possible employer, must be ready immediately to utilize as much of this manpower as possible. We can do this only by having detailed plans and specifications already prepared and by having financial arrangements ready in advance. We must be ready to put men to work constructively at once if we are to do our part in the most acute period of transition from war to peace.

The postwar water works job can be quickly outlined. Much deferred maintenance, rehabilitation and expansion will have to be done. The nation's problems involving transition from war to peace require that these water works activities proceed immediately at the war's end. The present day job of the water works industry is therefore clear: the rehabilitation and construction must be completely engineered and planned at the earliest possible time. Each water works management should be spending as much effort as possible, right now, in developing necessary plans and specifications covering postwar activities.

In developing these plans and specifications, the first question posed is: What materials will be available for postwar use? Will there be new and

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A paper presented on June 17, 1943, at the Cleveland Conference by W. Victor Weir, Supt., St. Louis County Water Co., University City, Mo.

revolutionary materials, equipment and processes? If so, or if not, we need to know the situation now, since the postwar construction we are now planning must embody the latest and best of the materials and equipment which will be available after the war. We must also know whether there are any new developments in the offing which might be important enough to warrant postponing immediate activity.

This report was therefore developed on the basis of answering these questions regarding materials necessary for rehabilitation and expansion of water works from the source of supply to the consumers' meters. There was only one way of answering these questions: asking the suppliers about the materials which would be available. Thus, letters were sent to approximately seventy companies engaged in supplying water works materials and equipment, asking whether they would have any new developments for postwar use. The responses to this inquiry were gratifying, replies being received from practically every company of importance in the field. As these responses were all received in June 1943, the information is essentially current.

Replies to Questionnaire

The following quotations from replies received indicate the general situation regarding postwar materials and equipment:

1. "While we are doing some postwar development work which will call for the use of some materials not previously used in our equipment, the development is not sufficiently far advanced so that it is possible to outline advantages or disadvantages of the particular material, nor do I feel that we can at this time forecast to what extent our development program will have progressed by the time the war is over. There is nothing I would like better than to give you some concrete examples of new material or equipment which would be available but, at the present time, such a forecast would come very much under the heading of idle speculation."

2. "Changes in design of centrifugal water works pumps during the war have not been radical. Therefore, municipalities receiving recommendations at the present time may feel assured that they will cover the designs and practice which will still be current when the war ends."

3. "In view of the long life expected from water works material and its frequent inaccessibility for repair in case of failure, manufacturers proposing to incorporate new materials in their products and offer them for sale without lengthy test periods, running into months or even years in the case of important changes, face a serious responsibility to their customers. This company is keeping closely in touch with all new materials and has run, and is running, many series of experiments which should result in better products in the future; however, none of our developments has reached the stage where we are prepared to predict that the products we expect to sell after the war will differ in any important respects from those which we sold before the war, insofar as new materials are concerned.

"New products available to us fall into three general classes:

a. Materials, previously well known, which will be available because the cost of them has been greatly reduced. Magnesium and many plastics, such as

lucite, vinylite, polystyrene, tygon, Saran and ethyl cellulose are examples of this class. All of them were well known in laboratories prior to the war, but were not produced in sufficient quantities or at a low enough price to permit their use in a large way in industry.

b. New products developed as the result of intensive research, financed by the government and war industries. Many ferrous and nonferrous alloys, particularly those involved in the use of rare metals, such as beryllium, tantalum, etc., fall into this class, which also includes process changes, such as the forming of sheets by stressing the surface over stretching dies, and the setting of precision punches in plastics instead of in cast-iron die-blocks.

c. New techniques for handling old materials, such as synthetic pressed plywood and powdered metals.

"By far the greater part of the development work which has been done during this war has been to find substitute materials to take the place of scarce products. We think it is safe to say that a relatively large proportion of substitute materials will be displaced by the original product as soon as it is again available; and this is more likely to be true in the water works field than in other industries where novelty often plays as large a part as performance in making sales.

"There will, however, be many cases where magnesium and aluminum, for example, will attempt to compete with cast iron by persuading the purchaser to offset weight against slightly higher price; but until the war is over and the postwar plans of the producers of various materials are known and have been subjected to the stress of competition, we can hardly predict which products will secure greatest acceptance. New processes will doubtless be employed, but the customer is not likely to be aware of them since he is not interested in whether a certain gear has been made of powdered metal or a casting, provided the final product is the same."

4. "There is no question but that the water works industry as a whole will eventually benefit immeasurably from war-induced discoveries and procedures. But this is important—very few industries have been so completely converted to war use as have the normal suppliers of equipment for this field. Manufacturers, such as ourselves, have probably been harder hit by war restrictions than most. Our consolation must be that there will be tremendous cumulative demands in the future. The reconversion to meet these demands will not take long, provided we make our products to the same designs and by much the same production procedures that were in effect before the war. Buyers of water works supplies should therefore not be disappointed with the apparent lack of the technical wonders that most have been led to believe would burst forth immediately upon signing the armistice.

"It takes time, both for tooling to manufacture and for field testing of new departures from previously accepted standards. Water works men are justly cautious in their acceptance of radical changes. Too much depends on the health and welfare of the public service they render to gamble on the untried and unproved. Therefore, most suppliers, such as ourselves, are utilizing the present time for progressive thinking and experimentation; but the war conversion of our factories, manpower and material shortages and

priority controls will not permit us to perfect our immediate ideas until after the war. . . .

"One very important point, to my way of thinking, is the increased accuracy and precision in manufacture that is going to be apparent in postwar equipment. Any firm handling a war contract has had the matter of manufacturing accuracy very forcibly demonstrated. Sloppy workmanship just doesn't go with the Army, Navy or Maritime Commission. Those accustomed to working to tolerances of hundredths of an inch had to learn to hold to thousandths in order to stay in business. New equipment, gages, etc., now used on war contracts will be available for peacetime application. The results of this closer control to accepted standards should be reflected in better performing, longer lasting water works supplies, having completely interchangeable parts."

5. "When it becomes available, it is certain that we shall be using much more aluminum in parts of our equipment than formerly and some more magnesium. It seems doubtful that we shall be making any wide use of plastics, except for such parts as can be machined, as our products do not run into sufficiently large quantities to use molded material of this sort."

Summary of Replies

The authors of these remarks will not be identified here, since their remarks are typical of many others received, which cannot be quoted because of lack of time and space. The replies to the inquiry, however, can be grouped in the following classes:

1. The majority simply stated that they would have no new postwar developments.

2. Several discussed the materials situation at considerable length, as in the above quotations.

3. A number mentioned comparatively recent developments, usually of the type consulting engineers or water works operators have been, or should already have been, advised of, or that will receive advertising publicity in the immediate future.

4. A few suggested that they would have some new developments after the war, especially in the fields of instruments and controls, but none stated that these developments would be basic changes.

Altogether, the responses were reassuring. The manufacturers supplying the water works industry have had their engineering and research departments on the alert. They are investigating the new plastics, alloys and other materials we have heard about, and a number we have not heard about. When new materials have proved themselves, they will be put to use, but not before. When they are offered, they will appear as refinements and improvements over past materials and equipment, but the chances are that people looking for great improvements will be sadly disappointed.

Auxiliary Power Developments

In the field of auxiliary power we can expect to see some postwar changes. High-speed diesel engines, now being made and to be available after the war, will tend to compete with gasoline engines as to first cost and with slow speed diesels as to fuel cost. These units are now being built on a semi-mass-production basis for military and naval purposes. Details are not now available for civilian information, but will be immediately after

the war. These units will find application for driving peak load booster pumps and as standby auxiliary power units for electric and slow-speed diesel prime movers. They will also find application for augmenting steam plants, where short summer peak loads get beyond the installed plant capacity. These units will occupy little space, will be moderate in first cost, will have low operating and moderate maintenance costs and will be reliable over moderately extended periods of operation.

Place of Electronics

This report would not be complete without discussing the place of electronics in the postwar picture. Advertisers have said that we are entering the electronic age. The public is, rightly or wrongly, expecting to have many of its burdens lightened when electronic miracles are shifted to peacetime rather than wartime uses. Many engineers are wondering whether electronic methods will be applicable in the fields in which they work.

By definition an electronic apparatus is "a device in which electric conduction current is carried through a vacuum or gaseous space." * A simple electronic device is the ordinary fluorescent lamp. Radio sets, photo-electric cells and the complicated radar instruments are likewise electronic devices. We have known of electronics for twenty years.

Electronic devices will probably find greater water works uses in the field of measurement and control, assisting in the measurement of such phenomena as temperature, pressure, turbidity, pH, color, specific gravity, liquid levels, etc., and in amplifying the resulting weak electrical impulses sufficiently to afford automatic control of pumps, heaters, chemical feeders, valves, etc. Electronic devices will find particular application in fields where speed of operation and control is essential. Often they will offer no advantage over electric, pneumatic, hydraulic and mechanical devices, especially where extreme speed of control is not a factor. In such cases, electric, pneumatic and hydraulic devices will have the advantages of simplicity and easy maintenance.

At the present time, there seem to be no electronic developments which would indicate that existing water works equipment will suffer galloping obsolescence, or that anything can be gained by waiting for electronics to produce any revolutionary equipment. We can, however, look forward to an increase in the use of electronic fluorescent lighting in water works plants. Also, the day may not be far off when the electronic microscope will be simplified and reduced in cost to the point where it may become a standard piece of water works laboratory equipment.

Development of Plastics

Since we have also been told that we are living in the plastics age, this report must properly consider that subject. The restrictions on the use of rubber and copper in the water works field have resulted in the introduction of several meritorious developments in tubing for the transportation of corrosive solutions. At the present time we can predict postwar competition between these materials and the materials we were using before the war. There appears to be no reason, however, for expecting synthetic and plastic prod-

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* JOSEPH SLEPIAN. Address before the Science Talent Inst. (March 1, 1943).

ucts to supplant the materials we were accustomed to specifying, which will undoubtedly all be available after the war.

Plastics can, in time, be expected to supplant hard rubber and possibly some bronze parts in water meters. Plastics may, however, find application in places where numerous low-stress pieces are required, which can be molded to required tolerances, such as ferrules in filter underdrains, floats, gage cases, etc.

Plastic impregnated and bonded plywood will find applications in the water works field, both for underwater and abovewater uses. Plywood water pipes have been made, but the present state of the art makes speculation as to the future merits of their application futile.

Application of New Law of Design

There is at least one new use of old material which should be mentioned, i.e., through the extended application of the American Standards Association Recommended Practice Manual for the Computation of Strength and Thickness of Cast-Iron Pipe.* Although this recommended practice referred to pit-cast pipe, the same law of design can be used for metals having higher physical characteristics.

We do not build a 20-in. concrete wall when the design says that a 15-in. wall is sufficient, nor do we install a 500-hp. motor when a 300-hp. one will carry the load. Since we now know how to compute the thickness of pipe for a given set of laying conditions, there is no excuse for arbitrarily specifying Class 100, 150 or 200 pipe, with a resultant waste of metal and money or an underguessing of the correct thickness with resultant ruptures. The new law of design has not received the attention it deserves. Its postwar use will be the equivalent of having a new material.

Conclusions

The conclusions from this investigation of postwar materials may be summed up as follows:

To Water Works Operators: The old standard purification and operating materials will be available without major competition from new products. Synthetic tubing will be available to compete with rubber, vitreous and glass tubing for conveying chemical solutions. In the distribution system the prewar materials will return, with little change, although time will bring normal improvements in materials and equipment.

To Water Works Management: There are no new materials, equipment or processes in the offing which indicate any basic changes in accepted water works design or practices. Planning and designing postwar rehabilitation and expansion projects should be prosecuted at once, since there are no indications of postwar developments which will have more than minor effect upon present day plans.

To Water Works Consultants and Designers: You and your organizations have been busy in helping water works supply the abnormal wartime loads, or your efforts have been temporarily diverted to other wartime activities. The water works industry should be demanding your services in the immediate future, so it is essential that you

* American Recommended Practice Manual for the Computation of Strength and Thickness of Cast-Iron Pipe—ASA–A21.2–1939. Distributed by A.W.W.A.

keep up to date with the improvements in materials and equipment which are slowly but surely continuing.

To Water Works Manufacturers and Suppliers: Many of you have made some new developments and applications which should be immediately publicized to the people who will soon be detailing plans and specifications for postwar work. You should continue to bear in mind the fact that water works men have not been stampeded into the belief that the end of the war will bring revolutionary materials and equipment. You will be expected to utilize light-weight alloys of aluminum and magnesium in pipe tapping and cutting machines, portable pumps, generators and other equipment where excessive weight is a burden. Applications of synthetics and plastics will be acceptable where they are improvements over past materials, or where economies will warrant their use. Electronic control may be an improvement in certain applications and you will be expected to utilize it where applicable. You should continue to remember, however, that novelty, for its own sake, has no interest to this industry. The materials and equipment you have been supplying have been eminently satisfactory as is witnessed by the long years of service they are rendering. We are willing to accept changes, but they must be genuine improvements as gaged by the service and life of the materials and equipment we are now using.

Studies Relating to Use of Saran for Water Pipes in Buildings and for Service Lines

By F. M. Dawson and A. A. Kalinske

THE critical shortage of copper has given impetus to the consideration of plastic materials for possible use in water service lines and for water pipes in buildings. Of all the plastics available at present a material known commercially as "Saran" (developed by the Dow Chemical Co.), and chemically as vinylidene chloride appears to have the best properties so far as use for small water lines is concerned. Saran is now being extruded in tubing form up to $\frac{3}{4}$ in. od.; and molded Saran flare-type fittings are available for use with this tubing. This material has been used for about two years for oil and gas lines around machinery and for conveying various corrosive chemicals in industrial plants, but this type of use has not given sufficient indication of how the tubing will behave under conditions encountered in water service lines and in the water pipes of plumbing systems.

This paper is a report of certain tests on Saran tubing and fittings made at the Iowa Institute of Hydraulic Research to determine how this material will behave when actually installed in water lines to and in buildings. The tests discussed herein include temperature, water-hammer and pressure-loss tests. Other tests are now being made, so this report should, in certain respects, be considered tentative.

Description of Material

Chemically, Saran is known as a vinylidene chloride polymer, having petroleum and brine as its basic raw materials. It is a thermoplastic; that is, it softens on heating and returns to its original condition on cooling. The base chemical is odorless, tasteless, nontoxic and nonflammable. Contrary to most plastics, Saran exhibits a crystalline structure, the arrangement of the crystals being heterogeneous for molded parts or extruded tubes and oriented for filaments and simple shapes which are stretched.

One of the most remarkable properties of Saran is its chemical resistance. At room temperatures it is extremely resistant to all acids and all common alkalies except concentrated ammonium hydroxide. Only a few of the less common organic compounds, such as dioxane and ethylene dichloride, will attack it. Of all the plastics, Saran has the lowest water absorption. In a 24-hr. test at 77°F., the absorption is zero, while in a 168-hr. test at 167°F., the absorption is 0.5 per cent by weight.

A paper presented on June 17, 1943, at the Cleveland Conference by F. M. Dawson, Dean, College of Engineering, Univ. of Iowa; and A. A. Kalinske, Asst. Prof., Univ. of Iowa, and Assoc. Director, Iowa Inst. of Hydr. Research, Iowa City, Iowa.

The specific gravity of the material is about 1.70.

The tensile strength of Saran varies from 4000 to 5000 psi. and it has a modulus of elasticity in tension of about 100,000. The strength changes appreciably with temperature (*see* Fig. 1), decreasing with increasing temperature. For instance, there is a change in fiber strength of 3 : 1 for a temperature change from 32°F. to 170°F. The material becomes less flexible at lower temperatures and is fairly brittle at freezing temperatures and below. The calculated bursting pressures for various sizes of the tubing at room temperature are given in Table 1.

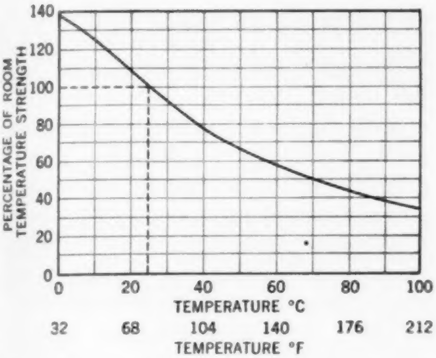


Fig. 1. Strength Variation of Saran Tubing With Temperature

One of the outstanding properties of Saran is its low thermal conductivity, which is characteristic of most plastics. For instance, the conductivity of Saran is 1/4500 that of copper. This is of considerable significance in regard to the use of this material for cold- and hot-water lines in buildings. A thermal property which will be a liability, so far as use of this material for piping systems is concerned, is its very high coefficient of expansion, amounting to 8.8×10^{-5} per degree Fahrenheit. This is 13.5 times that of steel. Thus, for a temperature change of 100°F., in a length of 100 ft. of pipe, there will be a linear change of 0.88 ft. Of course the flexibility of the tubing should make it fairly easy to take care of this item.

The manufacturer does not recommend the use of Saran for continuous temperatures above 170°F.; but intermittent temperatures up to 212°F. should be possible. The material begins to soften at 240°F. and melts at 310°F.

Tubing is now available in sizes from $\frac{1}{8}$ to $\frac{3}{4}$ in. od. of various wall thicknesses; and various type of flare-type fittings are being molded of the same material. It is contemplated that larger size tubing will be manufactured in the future. Saran pipe of iron-pipe size is available up to 4 in. in diameter, but its cost at present precludes its use for water services or in the plumbing system. This pipe can be threaded and put together with iron screw fittings or with Saran screw fittings of the same design as the iron type. Welded joints can be made by heating the ends of the pipe till softened, forcing them together firmly and allowing the joint to cool.

TABLE 1

Bursting Pressure for Various Sizes of Saran Tubing at Room Temperature

Tubing Size, od.	Wall Thickness	Bursting Pressure
in.	*in.*	*psi.*
$\frac{1}{8}$	0.031	650
$\frac{3}{8}$	0.062	1200
$\frac{1}{2}$	0.045	600
$\frac{1}{2}$	0.062	880
$\frac{5}{8}$	0.062	710
$\frac{3}{4}$	0.062	580

Temperature Tests

To obtain some data as to the temperature limitations in the use of Saran tubing for water lines, some tests were made on the bursting strength of the tubing with hot water inside. It should be kept in mind, of course, that, due to the low conductivity of the material, the entire tube wall is not at the temperature of the water inside. Thus, with water at 210°F. inside a $\frac{3}{4}$-in. tube with an 0.062-in. wall, it was possible to hold one's hand on the outside of the tube.

TABLE 2

Results of Temperature Tests on Saran Tubing of Various Sizes

Tubing Size, od.	Wall Thickness	Water Temperature	Pressure	Remarks *
in.	*in.*	*°F.*	*psi.*	
$\frac{3}{4}$	0.045	170	250	Tube burst—(3)
$\frac{3}{4}$	0.062	170	350	Tube burst—(6)
$\frac{3}{4}$	0.062	185	300	Tube burst—(4)
$\frac{3}{4}$	0.062	200	270	Tube burst—(8)
$\frac{3}{4}$	0.062	210	240	Tube burst—(7)
$\frac{5}{8}$	0.062	170	400	Joint pulled out
$\frac{5}{8}$	0.062	170	600	Tube burst
$\frac{5}{8}$	0.062	185	550	Tube burst—(1)
$\frac{5}{8}$	0.062	200	500	Tube burst—(2)
$\frac{5}{8}$	0.062	210	300	Joint pulled out
$\frac{5}{8}$	0.062	210	500	Tube burst
$\frac{1}{2}$	0.045	210	500	Tube burst—(5)

* Numbers in parentheses designate sample as shown in Fig. 2.

The tubing was tested by circulating water varying in temperature from 170°F. to 210°F. through various sizes of the tubing for at least 1 hr., then gradually raising the water pressure till failure occurred. The tubing was connected to iron pipe with flare-type fittings, the workmanship being only of average character. The test results obtained are shown in Table 2 and samples of the burst tubes are shown in Fig. 2. From the samples it will be noted that there appears to be a thinning out of the wall in most of the breaks. The flaring of the tube and making up of the joint had to be carefully done to prevent pulling out.

From these data, it appears that, so far as the static pressures ordinarily encountered are concerned, the tubing might be used for hot-water lines, especially with controlled water heaters. It should be remembered, however, that all water-piping systems develop water hammer, thus creating momentary pressures considerably above the static pressure.

Water-Hammer Tests

Owing to the high water velocity in the piping of buildings and the presence of numerous quick-closing faucets and valves, water-hammer pressures are developed continually in various parts of the piping system. Tests were therefore made to determine the effect of such water hammer on the Saran tubing installed with Saran flare-type fittings. The water-hammer pressure was created by closing a quick-acting valve suddenly, thus producing the maximum possible pressure. The pressure developed was recorded on a special gage arrangement. About 25 ft. of Saran tubing was connected at the end of about 100 ft. of straight $\frac{3}{4}$-in. iron pipe. The static pressure in the line was about 85 psi. Some of the results obtained are shown in Table 3. It should be pointed out, however, that the failures mentioned in the column headed "Remarks" are the results in only a few instances; in other instances nothing at all happened.

The maximum water-hammer pressure that it is possible to develop in Saran tubing varies according to the temperature, which causes changes in

the elastic properties of the material. To investigate this variation, tests were made after running water of various temperatures through the tubing. Results obtained are shown in Table 4.

In these tests, some difficulty was encountered with pulling of joints, especially with the $\frac{3}{4}$-in. tubing at the higher water temperatures. It is apparent that the maximum possible water-hammer pressure in Saran tubing decreases as the water temperature increases. There was, however, somewhat more tendency for the joints to pull with the hot water than with the cold water.

The above tests definitely indicated that the weak point was the flare-type fitting. These fittings were similar in design to the S.A.E. brass fittings for copper tubing. It appeared that, due to the flexibility of Saran, the fittings would have to be somewhat differently designed if they were to hold against water-hammer shocks. Thus, it was decided that two principal changes should be made: (1) the part of the fitting against which the inside of the flared tube rests should be roughened by forming concentric circles on the face so as to grip the tubing more firmly; (2) this roughened face and

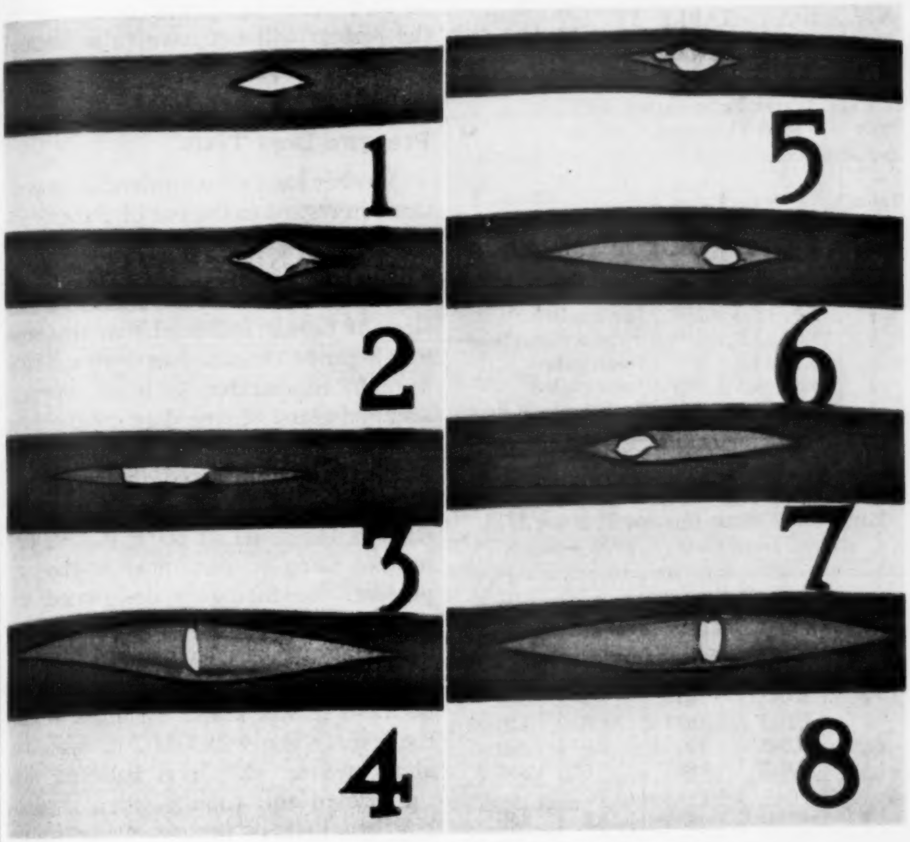


Fig. 2: Samples of Burst Tubing; data given in Table 2

the face inside the nut should not be parallel, but should have about a 10-deg. angle between them so that, on tightening, the faces would become parallel, thus giving more gripping surface against the tube.

Fittings with the above features were designed and tested in the same manner as the previous fittings. Except for one or two isolated cases, when it was considered that the joints were not made properly, the joints made with the new fittings did not fail and continually withstood shock pressures of the magnitudes shown in Tables 3 and 4.

TABLE 3

Results of Water-Hammer Pressure Tests on Saran Tubing of Various Sizes

Water Temperature, 40°F.; Wall Thickness, 0.062 in.

Tubing Size, od.	Water Flow	Water Velocity	Max. Pressure Developed	Remarks
in.	*gpm.*	*fps.*	*psi.*	
$\frac{3}{4}$	8.4	8.0	250	Joint pulled
$\frac{3}{4}$	16.5	15.8	450	Tube broke at flare
$\frac{3}{4}$	16.5	15.8	450	Joint leaked
$\frac{5}{8}$	8.8	14.1	268	Joint pulled
$\frac{5}{8}$	8.8	14.1	270	Tube broke at flare

TABLE 4

Variation of Water-Hammer Pressure With Water Temperature in Saran Tubing

Tubing Size, od.	Wall Thickness	Water Temperature	Water Flow	Max. Pressure Developed
in.	*in.*	*°F.*	*gpm.*	*psi.*
$\frac{1}{2}$	0.045	43	9.0	545
$\frac{1}{2}$	0.045	83	9.0	410
$\frac{1}{2}$	0.045	100	9.0	390
$\frac{1}{2}$	0.045	160	9.0	360
$\frac{3}{4}$	0.062	40	18.5	450
$\frac{3}{4}$	0.062	92	18.5	315
$\frac{3}{4}$	0.062	160	18.5	235

Due to the flexibility of the Saran tubing the maximum water-hammer pressure that can be developed will be only a third to a half of that which could be developed in iron pipe of the same internal diameter for the same rate of flow. In other words, Saran tubing affords considerable cushioning, so that other equipment connected to the system will not have to withstand excessive shock pressures. Also the hammer noises should be lessened.

Pressure Loss Tests

Another item of considerable importance in regard to the use of Saran tubing and fittings for water lines in buildings is the problem of pressure drop due to friction. Tests on the loss in various sizes of tubing indicated that this material can be classified as hydraulically smooth, comparable to brass, copper, lead and glass. Some data obtained on the $\frac{3}{4}$-in. od. tubing are shown in Fig. 3. It should be noted that the data follow the smooth-pipe law (the constant is for water at 60°F.). An important thing to remember is that, at present, the tubing is designated according to the outside diameter, which is contrary to the system used for designating pipe sizes for plumbing installation and service lines. In other words the $\frac{3}{4}$-in. tubing with 0.062-in. wall has about a $\frac{5}{8}$-in. id. It is believed that the size of this tubing, when used in any installations for conveying water, should not be less than that customarily specified when copper, brass or lead tubing is used.

Tests were also made on the loss in straight Saran couplings as used to join the tubing. In certain sizes of the fittings the internal diameter was less than that of the tubing. This is, of course, very undesirable for water piping installations. The data for loss in various sizes of Saran couplings, as

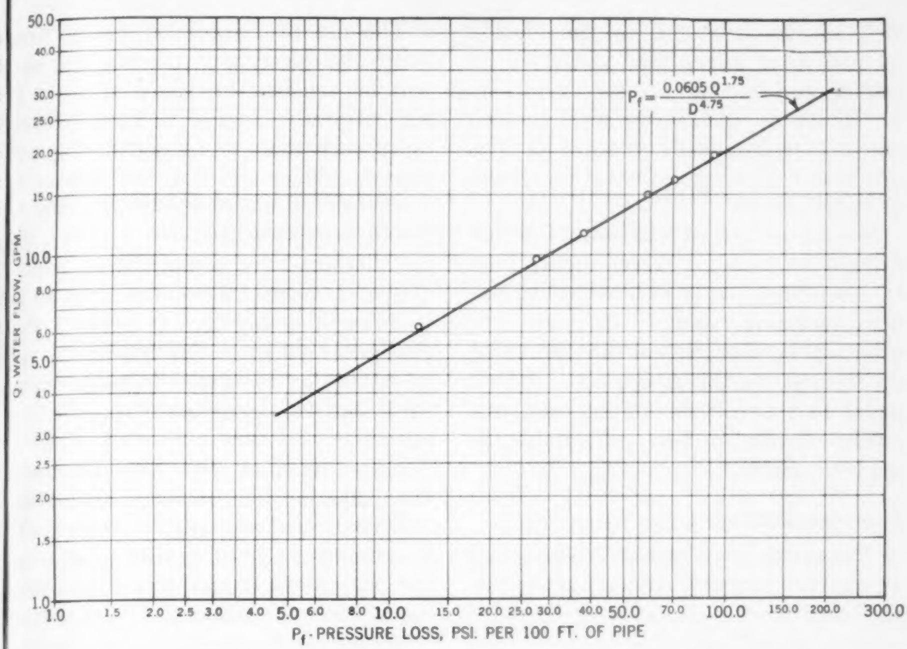


Fig. 3. Pressure Loss Data for ¾-in. od. Saran Tubing; wall thickness, 0.062 in. actual id., 0.632 in.

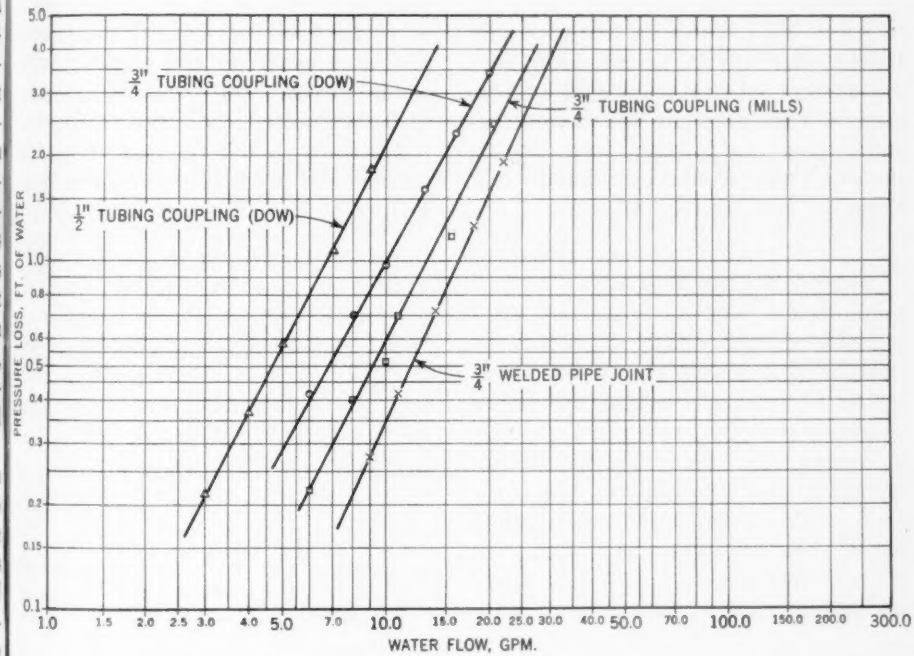


Fig. 4. Pressure Loss in Various Saran Coupling Joints

well as the loss due to the "bead" formed when Saran pipe is welded by heating and butting, are shown in Fig. 4. Tests on the Saran pipe showed that it is hydraulically smooth, its friction loss following the equation shown in Fig. 3.

So far as use of Saran tubing and fittings for building water-supply lines is concerned, it is believed that the manufacturers should designate the tube size by the internal diameter, that the fittings should have a bore at least equal to that of the tubing and that tubing having a $\frac{3}{4}$-in. id. should be made available.

General Items

The problem of whether rodents will attack this material under various installation conditions has been discussed and re-discussed. Laboratory tests with white rats indicated that these animals will begin to chew on the tubing when they are starved or deprived of water. What will happen with wild rodents can only be known from field experience. Tests with wild rats in cages did not give any worth-while results, since the animals were out of their normal environment and their behavior was entirely different.

The use of Saran for service lines raises the question of whether the pipe will be crushed by sharp stones. It will naturally have to be handled with more care than is copper tubing and heavy rocks should not bear against it. In Germany, where material similar to Saran has been used for services, the installations have some sort of a protective covering above the pipe so as to prevent crushing. It appears that Saran has sufficient flexibility so as not to burst due to water freezing inside of it, but this experience is quite limited.

Saran melts at about 310°F.; therefore, fire, or temperatures above this will destroy the piping. To what extent this item is of significance so far as use of the material for plumbing installations is a matter of conjecture.

Everything considered, it appears that the use of Saran tubing and fittings for cold-water lines inside of buildings and other accessible places is certainly worth trying. Short lengths of Saran such as for goosenecks in water service lines to buildings seem to be warranted; but its use for hot water lines should be very limited at present and installations made only on a more or less experimental basis.

Colorimetric Determination of Chlorine Residuals up to 10 ppm. With Ortho-tolidine

By N. S. Chamberlin and J. R. Glass

THE data presented in this paper, as well as those contained in previously published articles (1, 2), were accumulated in connection with research work undertaken by the A.W.W.A. Committee on Control of Chlorination. The earlier articles contained basic information relative to the reactions between ortho-tolidine and chlorine and served as a foundation for the present critical study of these same reactions, as applied to the accurate determination of residual chlorine.

Since the ortho-tolidine method is accepted as official by many technical organizations and is the colorimetric test in common usage at the present time, the procedures appearing in the present edition of *Standard Methods* (3) were studied in detail. In the first report of the A.W.W.A. committee (4), this phase of the work was outlined.

This paper presents a record of a visual and spectrophotometric study of the method of preparation of the ortho-tolidine-chlorine colors for residuals up to 10 ppm. chlorine and of a practical set of permanent chlorine standards to match these colors. It is divided into two parts: Part I, on the ortho-tolidine-chlorine colors, appears below and Part II, on the permanent chlorine standards, will appear in a later JOURNAL.

Part I—Production of Ortho-tolidine-Chlorine Colors

The development of the ortho-tolidine method for the determination of residual chlorine (5–8) at once, made chlorination a practical procedure, and in the ensuing years no better colorimetric method has been devised. As experience has been gained, the test and color standards have been improved gradually, and, as rapidly as these improvements have been confirmed, they have been incorporated into *Standard Methods*.

At the time of the latest revision of these standards (1936), it was recognized that two values could be obtained for a 1.0-ppm. residual at the point where the standards overlap. Furthermore, it was recognized that reproducible colors could not always be obtained, particularly for values of chlorine less than 1.0 ppm., where 1 ml. of standard ortho-tolidine per 100 ml. water was used. In practice, this difficulty was overcome by increasing the

A contribution by N. S. Chamberlin, San. Chemist, Technical Service Div., and J. R. Glass, Research Chemist, Research Labs., Wallace & Tiernan Co., Inc., Newark, N.J.

amount of ortho-tolidine or by adding supplemental acid.

These aberrations have pointed to the desirability of formulating a uniform procedure for all chlorine residuals up to 10 ppm. and one that will be favorable to procuring more reproducible results under adverse conditions. In connection with this, it is pertinent to quote Clark, Cohen and Gibbs (9), who stated that: "A color reaction to be safe must respond to one definite set of conditions and to one only."

The work described in the following pages was concerned with the determination of these conditions, in the study of which three main factors had to be considered: (1) the final ortho-tolidine concentration of the color mixture; (2) the final acid concentration or pH of the color mixture; and (3) the method of addition of the ortho-tolidine reagent.

Experimental Work

General Procedure

Chlorine waters were prepared by diluting "Zonite," a commercial hypochlorite. The chlorine waters used for the curves in Figs. 1 and 2 were standardized by the acid starch-iodide method given in *Standard Methods*. The chlorine waters used for all other curves in the experimental work were titrated amperometrically with sodium arsenite, following the technique outlined in the section entitled "Preparation of Temporary Chlorine Standards" (p. 1077).

All ortho-tolidine solutions were prepared from ortho-tolidine dihydrochloride as outlined under the section on "Preparation of Ortho-tolidine Reagent" (p. 1076). Colorless reagents, required for use in the spectrophotometric work, could not be obtained with the regular cp. ortho-tolidine. In those cases where the experimental work required either ortho-tolidine or hydrochloric acid beyond the solubility of ortho-tolidine, the excess of acid beyond this solubility was added as expediently as possible, i.e., as soon as some of the chlorine water had been added to the ortho-tolidine solution. All ortho-tolidine-chlorine color mixtures containing precipitates, as noted, either visually or spectrophotometrically, were discarded.

The spectrophotometric data were obtained on the General Electric Recording Spectrophotometer at Purdue University, Lafayette, Ind., and on a similar machine at the Electrical Testing Laboratories, New York City. A 10-mμ slit-width was used on both of the instruments. Transmission curves for the ortho-tolidine-chlorine colors were obtained by using a reference cell. This set-up is similar to that used in a comparator and thus gives the transmission factors for the ortho-tolidine-chlorine color only. Unless otherwise noted, recording of these curves started $\frac{1}{2}$ to $1\frac{1}{2}$ min. after the preparation of the color.

Effect of Ortho-tolidine Concentration

The effect of the ortho-tolidine concentration on the quantitative and reproducible yellow ortho-tolidine-chlorine color is quite pronounced. A deficiency of ortho-tolidine produces a different color—orange to red. This change in color is only slightly discernible for low chlorine residuals, but becomes more pronounced, both with increasing deficiencies of ortho-tolidine and with increasing chlorine residuals

The minimum amount of ortho-tolidine in the final color mixture is dependent upon the maximum chlorine residual to be tested, since an ortho-tolidine : chlorine ratio of at least 3 : 1 by weight must be maintained. Thus, the use of 5 ml. of ortho-tolidine reagent with 100 ml. of chlorine water up to 10 ppm. requires the use of a reagent containing *not less* than 0.60 g. ortho-tolidine per liter.

The maximum allowable amount of ortho-tolidine in the final color mixture depends upon its acidity. The acid : ortho-tolidine ratio must be *at least* 100 ml. concentrated hydrochloric acid per gram of ortho-tolidine. A ratio less than this causes fading, the color taking on a green hue. Still further lessening of the ratio causes such rapid fading that the change in hue is not noticed. A ratio greater than 100 : 1 increases the stability of the color.

An ortho-tolidine reagent containing 100 ml. of concentrated hydrochloric acid should not contain more than 1.0 g. ortho-tolidine per liter and preferably less, since this acid : ortho-tolidine ratio causes slight fading. Similarly, an ortho-tolidine reagent containing 150 ml. of concentrated hydrochloric acid, should contain not more than 1.5 g. ortho-tolidine per liter and preferably less, since this acid : ortho-tolidine ratio causes slight fading. If the ortho-tolidine reagent meets the above specifications, the volume of the reagent may be increased until it is equal to that of the chlorine water without causing fading.

Supporting Data—Effect of Ortho-tolidine Concentration

The curves of Fig. 1 show the color produced by adding 100 ml. of 2.0-ppm. chlorine water to 10 ml. ortho-tolidine reagent of various ortho-tolidine concentrations, but constant acidity. The curves of Fig. 2 show the colors produced by adding 100 ml. of 10.0-ppm. chlorine water to 100 ml. of ortho-tolidine reagent of various ortho-tolidine concentrations, but constant acidity. The constant acidity in the ortho-tolidine reagents consisted of 100 ml. concentrated hydrochloric acid per liter.

Curves 3, 4 and 5 of each figure are identical and represent the quantitative and reproducible yellow-holoquinone ortho-tolidine-chlorine color for the chlorine residual specified. These reproducible curves have one point in common as regards the ortho-tolidine reagent. In all six curves the ratio of ortho-tolidine to chlorine is 3 : 1 or greater. Thus, in order to obtain a reproducible color, the ortho-tolidine : chlorine ratio must be at least 3 : 1 by weight. Other curves for other chlorine residuals show the same minimum ratio.

When the quantity of ortho-tolidine used gives a ratio less than 3 : 1, the change becomes profound, as shown by an analysis of the curves. A rise in transmission throughout the visible spectrum denotes a decrease in the intensity of the same color. A comparison of Curves 2 and 1 with Curve 3 of both Figs. 1 and 2 shows increasing transmissions for Curves 2 and 1 from 400 to 480 mμ and a decrease in transmission from 490 to 600 mμ. Although not readily apparent, mathematical calculations would show the intensity of the color in Curve 2 to be greater than that in Curve 3 and the intensity of the color in Curve 1 to be only slightly less than that in Curve 3.

Of greater importance than the intensity of the color is the fact that, as the ortho-tolidine : chlorine ratio become less than 3 : 1 and is lowered to 2 : 1 and eventually to 1 : 1, the color itself changes. This is denoted by the spectral shift of the minima to the right in the spectrum and the lower transmission in the green and yellow portion of the spectrum. The color is shifting from the reproducible yellow, through an orange, to a red of entirely new spectral characteristics. When the ortho-tolidine is insufficient to provide even the 1 : 1 ratio of ortho-tolidine to chlorine, the spectral character of the red color is maintained, but there is a decrease in its intensity as would be denoted by higher transmission throughout the spectrum. The importance of these changes in color is that they are noticeable to the eye and become increasingly so with either increasing deficiencies of ortho-tolidine or increasing chlorine residuals.

That the red color was a matter of definite relative proportions of ortho-tolidine and chlorine was pointed out by Muer and Hale (10). That a constant and sufficient quantity of ortho-tolidine should always be used was also pointed out by Hale (11). Statements indicating that the minimum ratio of ortho-tolidine to chlorine for a full yellow-holoquinone ortho-tolidine-chlorine color must be 3 : 1 also appear in recent writings (1, 2, 4). From this evidence it can be concluded that the use of 5 ml. ortho-tolidine reagent with 100 ml. chlorine water requires a reagent containing not less than 0.6 g.

in intensity, as is noted by the rise in the minima of Curves 6, 7 and 8 of Figs. 1 and 2. The colors of each succeeding curve are also somewhat greener due to increasing absorption in the entire portion of the spectrum beyond 500 mμ. Spectrophotometric observations of the minima of Curves 6, 7 and 8 showed increasing transmission with time, indicating fading. This fading was much more rapid at the lower acid : ortho-tolidine ratios, a fact not always discernible from the curves. Slight fading was perceptible for some residuals even when the ratio of acid to ortho-tolidine was 100 : 1.

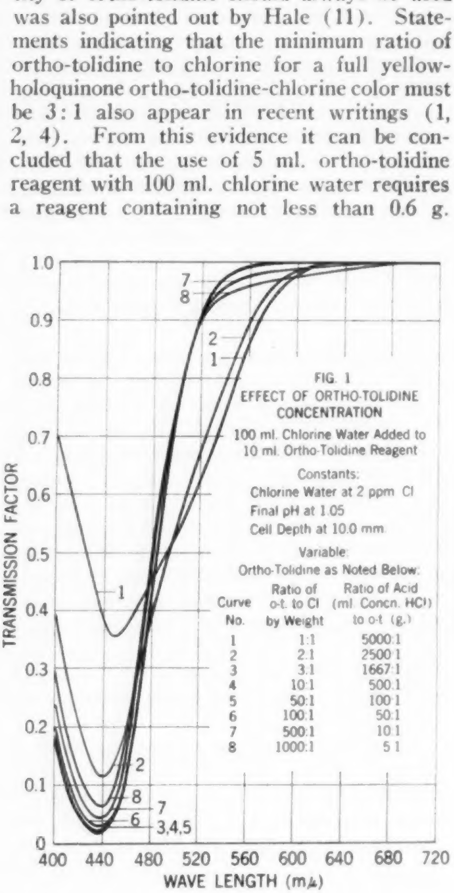


FIG. 1
EFFECT OF ORTHO-TOLIDINE CONCENTRATION

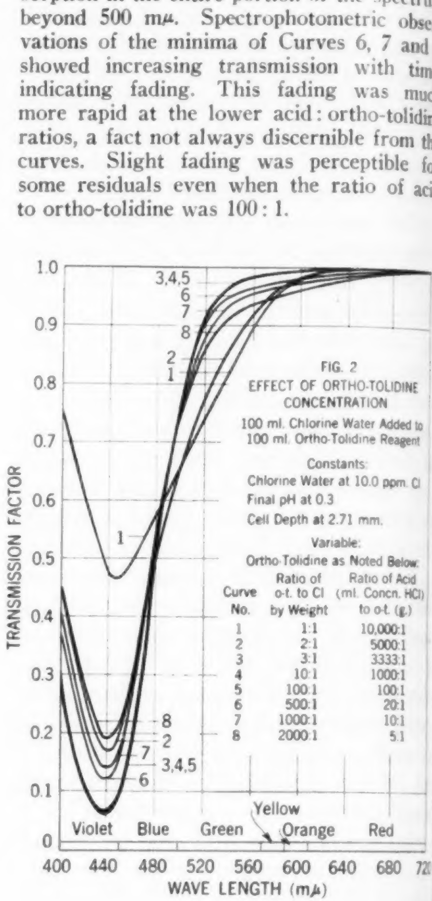


FIG. 2
EFFECT OF ORTHO-TOLIDINE CONCENTRATION

ortho-tolidine per liter for chlorine residuals up to 10 ppm.

The reproducible curves have one other point in common as regards the ortho-tolidine reagent. In all six curves, at the pH values specified, the acid : ortho-tolidine ratio is 100 : 1 or greater. To obtain a color that does not fade, the acid : ortho-tolidine ratio must be at least 100 ml. of concentrated hydrochloric acid to 1 g. ortho-tolidine. Other curves for other chlorine residuals show the same minimum ratio.

When the ratio of acid to ortho-tolidine becomes less than 100 : 1, the color decreases

That low concentrations of ortho-tolidine favor the formation of the holoquinone has been pointed out by Tarvin, Todd and Buswell (12). From the oxidation-reduction standpoint this is plausible. It is more so when one considers that 1 g. of ortho-tolidine per liter in decreasing concentrations of acid will cause noticeable fading and that increasing concentrations of acid will not only show no fading, but produce such complete oxidation as to shift the color toward the red.

That unstable blue meriquinones can be formed in acid as well as neutral or alkaline

solutions has been pointed out by Clark, Cohen and Gibbs (9). The formation of meriquinones (greener colors) at these acid concentrations appears evident from Curves 6, 7 and 8. That increasing quantities of a solution, containing 100 ml. concentrated acid and 1 g. ortho-tolidine per liter, can be added to water without producing fading is denoted by comparison of Curve 5 in Figs. 1 and 2. This has been pointed out by Almquist (13).

From this evidence it can be concluded that an ortho-tolidine reagent containing 100 ml. concentrated hydrochloric acid per liter should not contain more than 1 g. ortho-tolidine per liter and preferably less, since this acid : ortho-tolidine ratio causes slight fading.

Effect of Acidity or pH

The effect of acidity is without doubt the most important factor in obtaining a quantitative and reproducible ortho-tolidine-chlorine color. As early as 1913, Ellms and Hauser found the use of strongly acid solutions essential to the formation of a permanent yellow of more uniform gradation proportional to the chlorine added. The importance of an increase in the acid concentration of the final color mixture has been confirmed by many workers (6, 10–12, 14–21). Enslow (22, 23), in particular, has repeatedly advocated the use of more acid in the final color mixture.

By using sufficient acid to maintain the pH of the color mixture within a specific range under all conditions, it is possible to obtain a quantitative and reproducible ortho-tolidine-chlorine color. The minimum permissible pH value of the color mixture is 0.3 to 0.5, but, since it is impractical to obtain such a low pH value, this point need not be discussed further. The maximum pH is somewhat dependent upon the chlorine concentration. For chlorine residuals up to 10.0 ppm., the pH must not be more than 1.3.

With 100 ml. of chlorine waters up to 10.0 ppm., having alkalinities not in excess of 1000 ppm. as calcium carbonate, the use of 5 ml. ortho-tolidine reagent requires a reagent containing *not less* than 150 ml. concentrated hydrochloric acid per liter.

The above quantity of acid minimizes the interference of iron and nitrites. It is in excess of the amount specified by *Standard Methods* for eliminating these interferences. An additional advantage of this greater increase in acid in eliminating interference is that, due to the very rapid color development, the samples may be read sooner than permissible with the present *Standard Methods* technique. As a result, the time for an interfering effect to occur is less.

Increasing the acidity to within the pH range specified has a favorable effect upon the color formation, in that: (1) it increases the intensity; (2) it produces color almost instantly at room temperature; (3) it increases color stability; and (4) it produces a color that more nearly obeys Beer's Law, an important factor in considering permanent chlorine standards. All of these factors tend toward the production of a quantitative and reproducible color.

Decreasing the acidity of the color mixture produces everything undesirable in the color reaction.

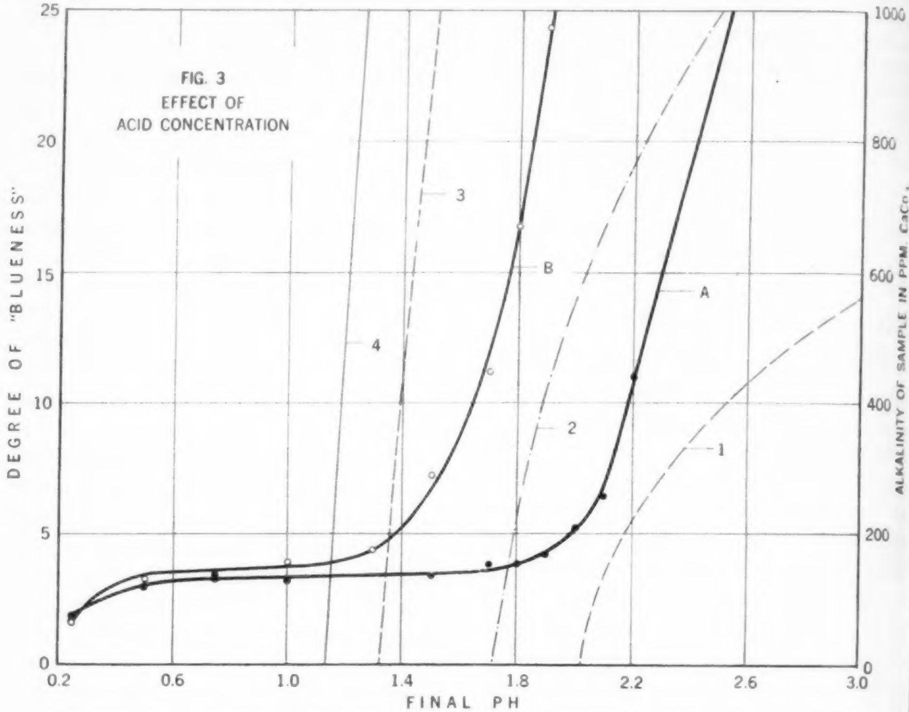
Supporting Data—Effect of Acidity or pH

The importance of the effect of pH on the ortho-tolidine-chlorine color makes it desirable to present both visual and spectrophotometric evidence of its effect.

The visual findings are shown in Fig. 3. In Curves A and B, all factors, except the pH, are kept constant. Curve A shows that the ortho-tolidine-chlorine color for 0.5 ppm. chlorine is decidedly bluer at the high pH values, but that the "degree of blueness" de-

creases rapidly as the pH value approaches 1.8. From a pH of 1.8 to a pH of 0.5 the color is constant, as indicated by the flat line produced by obtaining color matches with practically the same $CuSO_4$-$K_2Cr_2O_7$ standard.

Similar considerations are given to the ortho-tolidine-chlorine color in Curve B. This curve shows that the ortho-tolidine-chlorine color for 10.0 ppm. chlorine is bluer at much lower pH values than for 0.5 ppm.



"Degree of Blueness" is the quantity, in ml., of standard copper sulfate (Ellms and Hauser (6) and Muer and Hale (10)) in 100 ml. acid dichromate solution, equivalent in strength to 100 ml. dilute dichromate standard of Ellms and Hauser (for Curve A) and 100 ml. strong dichromate standard of Muer and Hale (for Curve B).

Curve A: 100 ml. of 0.50-ppm. chlorine water added to 5 ml. ortho-tolidine reagent containing 1 g. ortho-tolidine per liter and sufficient acid to give the final pH values shown; visual matching at 300-mm. cell depth

Curve B: 100 ml. of 10.0-ppm. chlorine water added to 5 ml. ortho-tolidine reagent containing 1 g. ortho-tolidine per liter and sufficient acid to give the final pH values shown; visual matching at 240-mm. cell depth

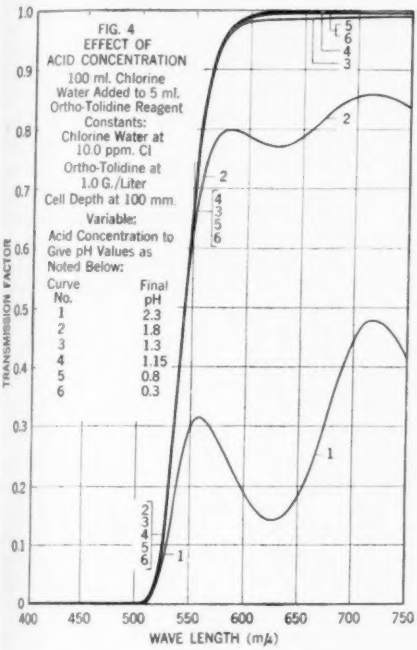
Curve 1: Final pH of the ortho-tolidine-chlorine mixture when 100 ml. chlorinated water of various alkalinities is added to 1 ml. standard ortho-tolidine reagent, as per *Standard Methods* procedure

Curve 2: Final pH of the ortho-tolidine-chlorine mixture when 100 ml. chlorinated water of various alkalinities is added to 2 ml. standard ortho-tolidine reagent, as per *Standard Methods* procedure

Curve 3: Final pH of the ortho-tolidine-chlorine mixture when 100 ml. chlorinated water of various alkalinities is added to 5 ml. standard ortho-tolidine reagent, as per *Standard Methods* procedure

Curve 4: Final pH of the ortho-tolidine-chlorine mixture when 100 ml. chlorinated water of various alkalinities is added to 5 ml. ortho-tolidine reagent containing 1 g. ortho-tolidine per liter and 150 ml. concentrated hydrochloric acid per liter

chlorine, but that the "degree of blueness" decreases rapidly as the pH value approaches 1.3. From a pH of 1.3 to a pH of 0.5, the color is practically constant, as indicated by the nearly flat line. The relative height of the flat portions of Curve A and B has no significance since $CuSO_4$-$K_2Cr_2O_7$ solutions and ortho-tolidine-chlorine solutions are not quantitatively proportional to each other. The significant relationship between the two curves is the pH value at which they begin to increase in their "degree of blueness."



The limits in pH observed for 0.5 ppm. chlorine closely approximate those for chlorine residuals up to 1.0 ppm. chlorine. When the ortho-tolidine-chlorine color exceeds 1.0 ppm. chlorine, the maximum pH limit decreases noticeably.

The 10-ppm. ortho-tolidine-chlorine color is chosen for the spectrophotometric study, since this chlorine residual has the narrowest pH limits for a reproducible color and, thus, is the one upon which the decision regarding the pH range depends. The spectrophotometric findings are given in the form of transmission curves in Fig. 4. These colors are for a constant cell depth of 100 mm. and, although the colors would be different spectrophotometrically and visually at other cell depths, they are satisfactory for related comparisons.

In Fig. 4, Curve 1 at a pH of 2.3 is decidedly not a spectrophotometric or visual match, being greener than the others. Curve 2, for a pH of 1.8, is also slightly green. Curves 3, 4, 5 and 6 for pH values 1.3 to 0.3, appear to be quite close spectrophotometric matches.

Curves that are spectrophotometric matches, i.e., that fall on top of one another, are also visual matches. Curves not spectrophotometric matches may be visual matches providing their differences are spectrally balanced.

To determine whether these curves are visual matches or not, it is necessary to evaluate the curves in terms of the trichromatic values and other monochromatic data for the normal eye in daylight. Table 1 gives the computed figures.

The trichromatic coefficients x, y and z (24), always totaling 1.0, have been converted into percentages and appear in the

TABLE 1

Effect of Acid Concentration or pH on Ortho-tolidine-Chlorine Colors

Curve No.	Final pH	Trichromatic Values			Least Square Sums	Dominant Wave Length	Relative Brightness
		Red	Green	Blue			
		%	%	%		mμ	%
1	2.3	47.14	52.37	0.49	78.71	574	18.7
2	1.8	52.48	47.22	0.30	2.10	582	52.2
3	1.3	53.45	46.28	0.27	0.01	583.5	61.2
4	*1.15*	*53.53*	*46.22*	*0.25*	—	*583.5*	*61.6*
5	0.8	53.70	46.05	0.25	0.06	584	60.9
6	0.3	53.78	45.98	0.24	0.12	584	60.6

tables under trichromatic values in percentages of red, green and blue designations which, although not exactly true, can be said to represent the three primary colors. To see how nearly these colors match the color at pH 1.15 (Curve 4, Fig. 4) the principle of least square sums has been applied to the trichromatic values. The dominant wave length is the wave length of the spectral region by which the color is most closely identified when illuminated by daylight. When the dominant wave lengths of several colors are close, they can be said to have similar hues. The relative brightness is based on the green primary, for this primary has been made to coincide with that point in the spectrum where maximum visibility to the eye occurs. The relative brightness value of black is 0 and that of white or colorless is 100.

From the table it is to be noted that good color matches are obtained for pH values from 1.3 to 0.8 when considering the three factors—least square sums, dominant wave length and relative brightness. If the pH value is lowered to 0.3, the color is still a close match, the least square sums not being excessive, although the relative brightness and dominant wave length would indicate that the color is slightly darker, but of the same hue. If the pH value is higher than 1.3, the chromaticity, hue and relative brightness change rapidly, denoting a rapid alteration in the color.

From the data presented in Figs. 3 and 4 and Table 1, it can be concluded that a reproducible ortho-tolidine-chlorine color can be obtained for chlorine residuals up to 10 ppm. provided that the pH of the color mixture does not exceed 1.3. The minimum pH of 0.3 to 0.5 is of small consequence, for it would be impractical to obtain such a low value.

That the pH range should be as low as designated above may be a surprise to some readers, for *Standard Methods* indicates that the proper color is developed below a pH of 4.0. This pH figure is common in the literature. McCrumb (19) has shown that the pH value must be not more than 2.0 to obtain a yellow color. That the pH should be less than 2.0 and apparently even under 1.0 in the final color mixture was announced by Enslow (22) and Harral and Jaffé (17). Dragt (15, 16), on the other hand, indicated that the final pH for chlorine residuals up to 1.0 ppm. should be less than 2.0 and preferably below 1.8, confirming the present findings for similar chlorine residuals.

In considering the acid strength of the ortho-tolidine reagent, it is essential that the acid be sufficient to take care of the alkalinities of water likely to be encountered. Only by accomplishing this can the green or greenish-blue colors, so troublesome to so many workers using the ortho-tolidine test, be eliminated and only by this method can a quantitative and reproducible color, comparable to temporary standards, be obtained.

In such a consideration, alkalinities up to 1000 ppm. as calcium carbonate have been taken into account. The pH values for various quantities of ortho-tolidine reagents of various strengths have been calculated and are shown in Fig. 3. This calculation is based upon the assumption that the activity coefficient of hydrochloric acid is 0.82 and that salts formed by neutralization of the alkalinity exert no buffering action on the final color mixture. Although not strictly true, this calculation is sufficiently exact to be applicable to potable waters. With highly polluted water or sewage, the exact amount necessary would have to be determined by experiment, since an appreciable amount of buffering material, in addition to the alkalinity, will be encountered.

Curve 1 represents the results with *Standard Methods* procedure, using 1 ml. ortho-tolidine reagent (containing 100 ml. concentrated hydrochloric acid per liter) per 100 ml. water. The curve shows that this provides a pH barely sufficient for temporary chlorine standards. Any formidable increase in alkalinity above zero in a sample would result in a green color, for this is probably the critical pH where greener colors become pronounced. The difficulty with this procedure is obvious. It is no wonder that Boruff, Vellenga and Phelps (25), Tiedeman (21), Enslow (22, 23), Rudolfs and Gehm (20), Tarvin, Todd and Buswell (12), McCarthy (18), Lea (26), Cox (27), Scott (28), Almquist (13), Buswell and Boruff (29), Harral and Jaffé (17) and others recommended the use of more ortho-tolidine reagent or an increase in its acid strength. An A.W.W.A. committee report (30) in 1928 recommended that the ortho-tolidine solution be made as acid as possible.

Curve 2 represents the results with one of the alternate procedures in *Standard Methods*, using 2 ml. of ortho-tolidine reagent (containing 100 ml. concentrated hy-

drochloric acid per liter) per 100 ml. water and the recommendation of Dragt (15, 16) that 1 ml. ortho-tolidine reagent (containing 200 ml. concentrated hydrochloric acid per liter) per 100 ml. water be used. This maintains a pH sufficiently low for most waters for chlorine residuals up to 1 ppm., but in cases where the alkalinity of the water exceeds 200 ppm. the proper pH would not be maintained. For chlorine residuals up to 10.0 ppm. chlorine, the reagent and quantity thereof are very decidedly inadequate.

Curve 3 represents the results with *Standard Methods* procedure for chlorine residuals from 1.0 to 10.0 ppm. chlorine, a method which uses 5 ml. ortho-tolidine reagent (containing 100 ml. concentrated hydrochloric acid per liter) per 100 ml. water. This curve demonstrates that this reagent provides a sufficient amount of acid for temporary chlorine standards. With high alkalinity waters, the color would be noticeably greener.

To obtain safely a quantitative and reproducible ortho-tolidine-chlorine color in water samples of alkalinities up to 1000 ppm. and chlorine residuals up to 10.0 ppm., it is essential that more acid be used than heretofore prescribed. Curve 4 represents the results with a procedure, recommended by the authors, using 5 ml. ortho-tolidine reagent (containing 150 ml. concentrated hydrochloric acid per liter) per 100 ml. chlorine water. The pH of the temporary standards will be 1.15. The final pH for water containing 1000 ppm. alkalinity will be 1.25. This procedure will therefore provide a pH value that does not exceed 1.3. It is obvious that at least this much acid is required. In the *Standard Methods* procedure for sewages, it is recommended that 10 ml. of an ortho-tolidine reagent (180 ml. concentrated hydrochloric acid per liter) per 100 ml. of sewage be used. This is a worthy recommendation since sewage contains other buffering materials in addition to alkalinity.

Since the increased acidity affects the oxidation-reduction potentials of the materials present in the color mixture, the interference of these materials is likely to be changed. It is worth while to note the work that has been done in this connection. Dragt (15) showed that, as the pH is lowered, the effect of iron interference is lessened. Scott (28, 31), Tarvin, Todd and Buswell (12) and others have recommended the use of more ortho-tolidine, ortho-tolidine in additional acid or ortho-tolidine and additional acid to eliminate the interference of iron. This recommendation appears in *Standard Methods* as a modification of the usual procedure, which specifies the use of 1 ml. standard ortho-tolidine and 1 ml. hydrochloric acid reagent. The amount of acid specified above is in excess of this. Experiments conducted by the authors indicated only traces of color produced in 5 min. by 1.0 ppm. of iron.

The interference of manganese is practically the same with either the *Standard Methods* procedure or with the amount of acid specified in this paper, since the reduction of manganic manganese by either reagent is practically quantitative.

Tarvin, Todd and Buswell (12), Dragt (15) and Scott (*32*) have studied the effect of increased acidity upon the nitrite interference. All agreed that increasing the acidity lessened and practically prevented the interference of small concentrations of nitrites. The modification for nitrites appearing in *Standard Methods* is identical to that used for iron. The amount of acid recommended in this paper provides the needed acidity. Since the interference of nitrite is a very complex reaction, however, it is impossible to state what the effect of high acid concentration would be on high concentrations of nitrites.

Increasing the acidity of the final color mixture has several very desirable effects. It increases the intensity of the yellow color. Tiedeman (21), Muer and Hale (10), Rudolfs and Gehm (20), McCarthy (18) and others noted that an increase in the acidity of the color mixture increased the intensity of the yellow color. This is due to the fact that the colors at the lower acidities were outside the range of the quantitative and reproducible yellow ortho-tolidine-chlorine color. As the acidity increases, the loss of color due to the blue meriquinone becomes less and, in its stead, more of the quantitative yellow holoquinone is formed, until the reaction becomes so complete that any further increases in acidity cause little or no increase in the intensity of the yellow color. Many spectrophotometric curves (not shown here) have recorded similar results. These observations are also substantiated by Figs. 3 and 4 and Table 1. In Table 1, it is demonstrated that as the pH values decrease from 2.3 to 1.3 and the acidity increases, the amount of the blue component of the color decreases, thereby increasing the intensity of the yellow color.

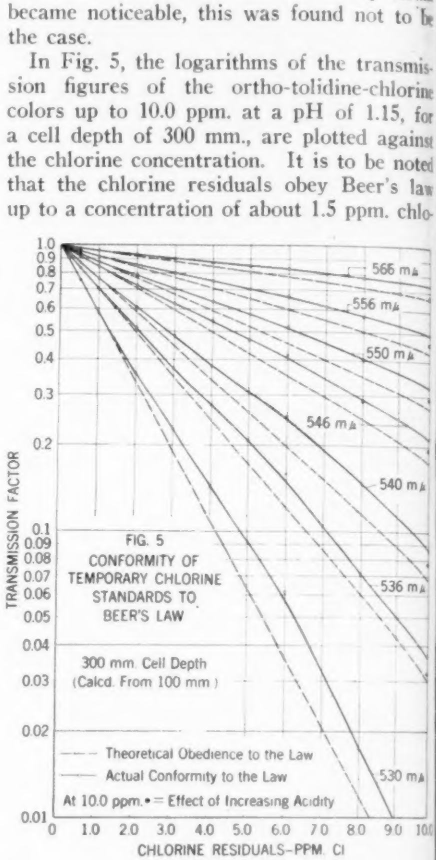
Increasing the acidity of the final color mixture increases the rate of color development as already pointed out by Enslow (22, 23), Tiedeman (21) and others. Dragt (15, 16) showed that the color reached its maximum almost instantaneously at room temperature for chlorine residuals up to 1.0 ppm. and pH values of 1.8 or less. Since the time for color development is so short, it cannot be confirmed spectrophotometrically, but visual observations at room temperature indicate that the rate of color development is practically instantaneous for all chlorine residuals from 0.05 ppm. to 10.0 ppm. in color mixtures having a pH of 1.3 or less.

Increasing the acidity to the point where both the quantitative and reproducible color and the most stable color are produced are almost synonymous. When insufficient acid is present, green or greenish-blue meriquinones of ortho-tolidine are produced. As many readers have no doubt observed and as Clark, Cohen and Gibbs (9) have been careful to point out, meriquinones of ortho-tolidine, even in fairly acid solution, are most unstable. As the acidity is increased and the pH values lowered, the proportion of meriquinone to the stable holoquinone decreases, as shown in Fig. 4, and eventually the reaction becomes primarily one in which only the yellow holoquinone is formed. Then maximum stability manifests itself. This occurs in the pH range, already defined, for quantitative and reproducible colors. In Fig. 6 (p. 1079), spectrophotometric curves are presented showing the stability of 0.5-ppm. chlorine colors in the dark at a pH of 1.15, which is within the recommended range. The lower the transmissions at the minima, the greater is the depth of color. Curves 1, 2, 3 and 4 represent color development times of 2, 6, 15 and 30 min. Not until 30 min. have elapsed has the color faded to any degree and, even then, fading is not appreciable.

Increasing the acidity produces a color more nearly obeying Beer's law, i.e., the law that the logarithms of the transmission factors at any given cell depth are directly proportional to the concentrations of the color. In his spectrophotometric work on orthotodiline-chlorine colors up to 1.0 ppm. chlorine, using 1 ml. standard ortho-tolidine per 100 ml. water, Dragt (15, 16) concluded that Beer's law was obeyed for chlorine concentrations up to 0.1 ppm. but not for concentrations from 0.1 to 1.0 ppm.

The use of the recommended quantity of acid at cell depths of 2.71 mm. and 10 mm. indicated that the ortho-tolidine-chlorine colors from 1.0 to 10.0 ppm. obeyed Beer's law at a pH of 1.15. At larger cell depths, where differences in the red end of the spectrum became noticeable, this was found not to be the case.

In Fig. 5, the logarithms of the transmission figures of the ortho-tolidine-chlorine colors up to 10.0 ppm. at a pH of 1.15, for a cell depth of 300 mm., are plotted against the chlorine concentration. It is to be noted that the chlorine residuals obey Beer's law up to a concentration of about 1.5 ppm. chlo-



rine, but that thereafter divergence from the law occurs at a constant rate. The obedience, to Beer's law, of chlorine residuals from 0.1 to 1.5 ppm. appears to be dependent upon the acidity.

If the color were a mixture of the meriquinone and holoquinone of ortho-tolidine in varying proportions, the law would not apply. If the color for all chlorine residuals up to 1.0 ppm. chlorine continually consisted of color molecules of one definite composition, it would have been possible for Beer's law to be observed. Figure 3 indicates that the full holoquinone color was not being

obtained for all chlorine residuals up to 1.0 ppm. by using 1 ml. of ortho-tolidine per 100 ml. of water.

It is interesting to find out whether further increase in acidity would cause the chlorine residuals from 1.5 to 10.0 ppm. to obey Beer's law. The figures for acidities sufficient to lower the pH of the 10-ppm. chlorine color to 0.3 are indicated by solid points in Fig. 5. It is to be noted that the increase in acidity causes a nearer obedience to Beer's law. It would seem that the higher the chlorine residual, the more difficult it is to obtain a complete yellow holoquinone reaction. Since the colors are stable and quantitatively reproducible and since they deviate from Beer's law at a constant rate, the addition of more than the recommended amount of acid is not warranted.

Effect of Method of Adding Reagent

The ability to obtain quantitative and reproducible colors and to arrive at the results presented above depended in no small measure upon the fact that the chlorine water was added to the ortho-tolidine reagent and that this was accomplished with continuous mixing. If a comparator cell or tube is of such great depth as to make good constant mixing impossible, the chlorine water should be added to the ortho-tolidine with continuous mixing in another vessel and then transferred to the comparator cell or tube.

The addition of the ortho-tolidine to the chlorine water produces erratic results. The color mixtures are usually lighter, particularly with low chlorine residuals, although they may be darker, particularly with higher chlorine residuals. This procedure causes delayed mixing and usually a loss of the chlorine through its contact with chlorine-consuming material in the comparator cell or tube. Unless extreme precautions are taken the extraneous material will always be present. If the chlorine water is added to the ortho-tolidine, however, the color will be formed before the chlorine can react with any of the extraneous material. The addition of the ortho-tolidine last cannot be considered a more desirable procedure.

Supporting Data—Effect of Method of Adding Reagent

The spectrophotometric curves in the supporting data presented above (p. 1067 *ff.*, p. 1069 *ff.*) were obtained by adding the chlorine water to the ortho-tolidine reagent with continuous mixing. That it was possible to obtain quantitative and reproducible colors attests to the fact that this is the proper technique to be pursued. The ability to use ortho-tolidine as an equal or better acceptor of the chlorine than other chlorine-consuming substances no doubt accounts for the reliability of this procedure. That good constant mixing is essential is evident from certain data already presented.

It has already been shown that, when the color is developed within the proper pH range, the quantitative yellow holoquinone is always produced (*see* Figs. 3 and 4 and Table 1). It has already been pointed out, too, that, if sufficient ortho-tolidine is present at all times, the quantitative reproducible yellow color, is formed instead of the orange or red color, (*see* Figs. 1 and 2). It has previously been noted that the use of any quantity of ortho-tolidine reagent containing an acid : ortho-tolidine ratio greater than 100 : 1 would prevent fading.

When chlorine water is added to a proper ortho-tolidine reagent with good mixing, the conditions for quantitative and reproducible color formation have been adhered to. At no time during the addition of the chlorine water to the ortho-tolidine are any of the conditions as regards acidity, ortho-tolidine concentration or ratios of each to the other violated.

If ortho-tolidine is placed in the bottom of a long comparator tube and chlorine water then added, the delayed mixing will produce conditions similar to those described below with accompanying erratic results. Under such circumstances the chlorine water should be added to ortho-tolidine with continuous mixing in a more appropriate vessel and then poured into the comparator tube.

Many spectrophotometric curves have been obtained by pursuing the technique of adding ortho-tolidine reagents to the chlorine water. The failure of this procedure to yield repro-

ducible colors attests to its unreliability. That the results were erratic, sometimes higher as well as lower, shows that they were not always in error due to the presence of chlorine-consuming extraneous material. That delayed mixing was the cause of this is evident from data already presented.

It has already been shown that when the color is not developed within the proper pH range, the quantitative holoquinone is not produced due to meriquinone formation (*see* Figs. 3 and 4 and Table 1). It has already been pointed out, also, that merquinones are unstable. Laboratory work has shown that once meriquinones are formed they cannot be converted quantitatively over to the yellow holoquinone on addition of more ortho-tolidine reagent, presumably because of this instability. It has recently been pointed out (2), that, when the ortho-tolidine : chlorine ratio is less than 3 : 1, the stable red compound is formed even when insufficient acid is present. Laboratory work has shown that, once any amount of the red compound is formed, it cannot be converted to the yellow holoquinone on addition of more ortho-tolidine reagent, presumably because of its very decided stability.

When ortho-tolidine is added to chlorine water, various portions of the mixture are deficient in acid and ortho-tolidine due to the delayed mixing. In this interim the conditions mentioned above exist. With low chlorine residuals, the tendency would be to form the unstable meriquinone. On mixing, a lighter color would result due to the failure of the unstable meriquinone to be converted quantitatively over to the yellow holoquinone. With high chlorine residuals, the tendency would be to form the red compound. On mixing, a darker color would result due to the failure of some of the stable red compound to be converted over to the yellow holoquinone. As a result, discrepancies, depending somewhat upon the magnitude of the chlorine residual, would be noticed.

Preparation of Ortho-tolidine Reagent

To obtain a quantitative and reproducible ortho-tolidine-chlorine color for waters containing up to 10 ppm. chlorine and 1000 ppm. alkalinity, it is essential that both the quantity of ortho-tolidine and acid in the reagent conform to the specifications already set forth. If the ortho-tolidine reagent is used at the rate of 5 ml. per 100 ml. of chlorine water, it is stipulated that the ortho-tolidine solution contain not less than 150 ml. concentrated hydrochloric acid per liter and that the ortho-tolidine concentration, under such circumstances, be not more than 1.50 g. per liter, nor less than 0.60 g. per liter. Giving consideration to a factor of safety it is apparent that the use of 1.0 g. of ortho-tolidine is in order. Although further increase in the acid might be desirable, the solubility of the ortho-tolidine in the acid must be considered.

Ellms and Hauser (6) and early editions of *Standard Methods* prescribed the use of 1 g. ortho-tolidine dissolved in 1 liter of 10-per cent hydrochloric acid (236 ml. concentrated acid per liter). McCrumb (19) reported this amount of ortho-tolidine to be barely soluble in 236 ml. concentrated hydrochloric acid per liter at room temperature and therefore recommended the use of 200 ml. concentrated hydrochloric acid per liter. Boruff, Vellenga and Phelps (25) found 178 ml. concentrated acid per liter satisfactory at a similar temperature (23.6°C.) and 150 ml. satisfactory for four days at 14°C. Laboratory tests have indicated that 180 ml. concentrated hydrochloric acid per liter will not cause precipitation above 7°C., but that 150 ml. concentrated acid will keep 1 g. ortho-tolidine in solution at 0°C. for several days. This evidence indicates that the use of a reagent containing more than 180 ml. concentrated hydrochloric acid per liter is not practical, for, once the dihydrochloride has precipitated, it is very difficult to redissolve. Since the precipitation might

not be noticed, there is always danger of an unsatisfactory reagent being used.

If it is desired to prepare the prescribed ortho-tolidine reagent starting with ortho-tolidine, the excellent and practical method of Theriault (33, 34), appearing in *Standard Methods*, can be employed. The strength of the dilute acid needs merely to be increased by using 150 ml. concentrated hydrochloric acid. Boruff, Vellenga and Phelps (25), as well as the authors, have easily prepared ortho-tolidine solutions containing at least this much acid. Attention has been called to the fact that trouble is at times experienced with the method. The facts to remember are that ortho-tolidine is insoluble in water, but that the dihydrochloride is soluble. A deficiency of acid or insufficient grinding of the ortho-tolidine in the mortar will prevent the complete formation of the dihydrochloride. The addition of sufficient water will cause solution of the dihydrochloride on stirring or shaking, but this procedure will be rendered difficult if too much of the diluted acid was added originally. Solution should be complete before the addition of the remainder of the dilute acid, for that, in turn, hinders the solution of the undissolved dihydrochloride.

In the work described here, the ortho-tolidine reagent was prepared from ortho-tolidine dihydrochloride rather than ortho-tolidine, because the latter always gave some color in the reagent. This color should be avoided even in routine work. When ortho-tolidine is purified with alcohol, as prescribed in early editions of *Standard Methods*, or with some other organic solvent, a product which has, or soon acquires, color, is obtained. If ortho-tolidine is purified with concentrated hydrochloric acid, the snow-white, water-soluble dihydrochloride is obtained. A product thus obtained has remained pure white for over a year in a tightly stoppered brown bottle.

The procedure of preparation of this ortho-tolidine reagent with the dihydrochloride, obtainable at some chemical houses, is simple. It involves weighing out and dissolving 1.35 g. of the dihydrochloride (a quantity equivalent to 1 g. ortho-tolidine) in 500–600 ml. distilled water, adding 150 ml. concentrated hydrochloric acid, diluting to 1 liter with distilled water, and mixing.

Preparation of Temporary Chlorine Standards

The solutions used in the preparation of temporary chlorine standards are as follows:

Stock Sodium Hypochlorite Solutions: These solutions are prepared by diluting "Zonite" with zero-demand water and storing in a bottle painted black on the outside. In this way, a stable solution is obtained. A stock solution of approximately 10 ppm. chlorine is used for residuals up to 1.0 ppm. and a stock solution of approximately 100 ppm. chlorine is used for chlorine residuals from 1.0 to 10.0 ppm. The bottle is connected to a buret by means of glass tubing so that measured quantities can readily be withdrawn. No grease is used in the stopcocks.

Zero-Demand Water: Adams and Buswell (35), Buswell and Boruff (29), Dragt (15) and others prepared the water by treating distilled water with chlorine and, then, after a short retention period, boiling for 30 to 40 min. This recommendation is given in *Standard Methods*. A more satisfactory and more easily prepared water is obtained by treating 5-gal. portions of distilled water with sufficient hypochlo-

rite to give an initial residual of 1.5 to 2.0 ppm. chlorine and enough phosphate buffer to obtain a 0.001 molar solution of pH 7.4. Several stoppered carboys of the water are allowed to stand in the sunlight until the chlorine is destroyed. Considerable time is often required, but by using several bottles in rotation, time is not an important factor. By this procedure no trouble is experienced and boiling off the excess chlorine is avoided. No loss in volume occurs and the possibility of getting foreign matter in the water is eliminated.

Standard Sodium Arsenite: The sodium arsenite solutions are standardized against iodine. The iodine is standardized against Bureau of Standards arsenious oxide.

Potassium Iodide Solution: A 1-per cent solution in zero-demand water is used.

The temporary chlorine standards are prepared by bureting, into a precalculated volume of zero demand water in an Erlenmeyer flask, a calculated quantity of sodium hypochlorite, so that, upon the addition of the latter, the total volume is 500 ml. of an approximate desired chlorine residual. After thorough mixing, a 100-ml. aliquot is pipeted into a smaller Erlenmeyer flask containing 5 ml. of the ortho-tolidine reagent. The chlorine water is added slowly. The needed amount of the color mixture is then poured into the comparator tube preparatory to matching. The remaining 400 ml. of chlorine water is poured into a beaker containing 0.5 ml. KI solution and most of the standard arsenite required. Its chlorine value is immediately determined by titrating amperometrically with the remainder of the standard arsenite solution, using an apparatus similar to that described by Marks and Glass (36). All glassware, including comparison tubes, is thoroughly cleaned with chlorine water prior to use and many sample runs made before a series of temporary standards, so prepared, are used for comparison. All the Nessler tubes or cells required are filled with chlorine water for a few hours before use. The ortho-tolidine-chlorine mixture is not allowed to remain in the tube longer than necessary.

By taking the necessary precautions, an excellent set of temporary chlorine standards can be prepared. Since the exact value of each standard is determined by direct titration, no assumptions are necessary regarding the zero-demand water. The authors' results indicated that the zero-demand water used had an average demand of 0.01 ppm. for residuals up to 1.0 ppm. and 0.03 ppm. for residuals from 1.0 to 10.0 ppm. The addition of the chlorine water to the ortho-tolidine eliminates many losses, since ortho-tolidine is a better acceptor of the chlorine than any extraneous material having a chlorine demand. In preparing temporary chlorine standards, Dragt (15, 16) added ortho-tolidine to the strong chlorine water before diluting. Muer and Hale (10) added ortho-tolidine to the dilution water prior to adding the chlorine water. Both followed this procedure to avoid the effect of the dilution water and to make use of ortho-tolidine as a better acceptor of the chlorine. The procedure outlined in this paper is advantageous in that through the use of the apparatus referred to, it has been possible to prepare temporary chlorine standards in the same manner as the procedure recommended for use with samples, i.e., adding chlorine water to ortho-tolidine

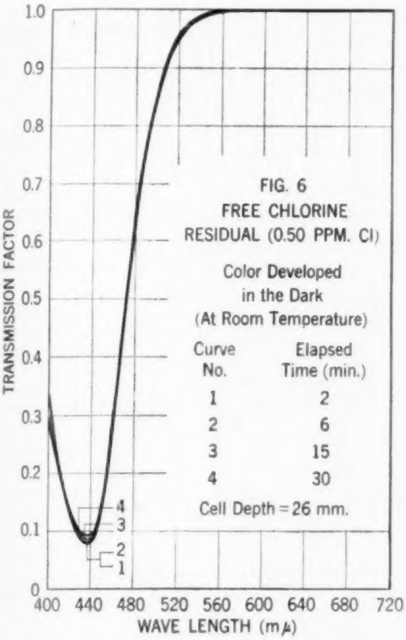
Color Characteristics of New Temporary Chlorine Standards

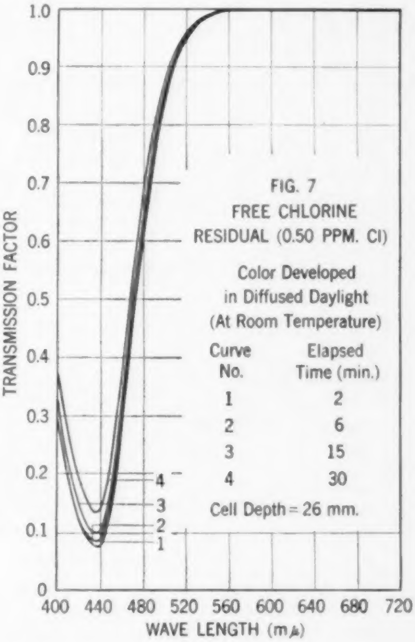
The colors for chlorine residuals up to 1.0 ppm. by the procedure recommended here are of greater intensity than those produced by following *Standard Methods* procedure, primarily because of the increased acidity in the final color mixture.

The color is produced almost instantly.

The color is quite stable in the dark, but to a decidedly lesser degree in lighter in 15 min., it is decidedly lighter in 30 min. Obviously, the standards should be kept in the dark.

The color conforms to Beer's law, as previously discussed, for chlorine residuals up to about 1.5 ppm., but divergence from this law occurs at higher chlorine residuals. This is indicated in Fig. 5, where the logarithms of the transmission factors at 300 mm. cell depth have been plotted against the





diffused daylight. The transmission factors at the minima of the curves in Figs. 6 and 7 indicate the degree of this stability over a 30-min. period. The higher the transmission factors the lighter is the color. Figure 6 indicates that, if the standards are kept in the dark, the color is only slightly lighter after 30 min. Figure 7 shows that the fading is appreciable in diffused daylight. While the color is only slightly concentrations of chlorine. If the colors obeyed Beer's law up to 10.0 ppm., they would follow the straight dotted line. The divergence appears to proceed at a fairly constant increasing rate with increasing chlorine residual.

The color of the various chlorine residuals at 26 mm. and 300 mm. is represented by the transmission factors presented in Figs. 8 and 9. Increasing absorption both with increasing chlo-

rine concentration and increasing cell depth in the blue end of the spectrum indicate that the colors are becoming more yellow and more intense.

The color changes are best presented by the compilation of some of the monochromatic data obtained from these curves, presented in Table 2. The calculations are based on observations by the normal eye in daylight. Brief definition of these values, except that of purity, representing the chromatic val-

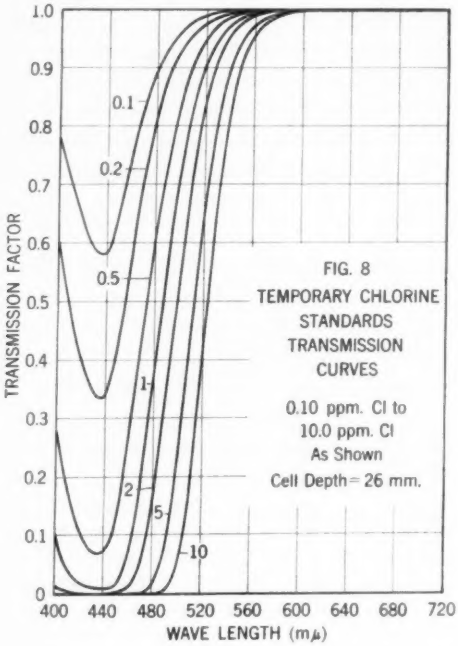


FIG. 8
TEMPORARY CHLORINE STANDARDS TRANSMISSION CURVES
0.10 ppm. Cl to 10.0 ppm. Cl As Shown
Cell Depth = 26 mm.

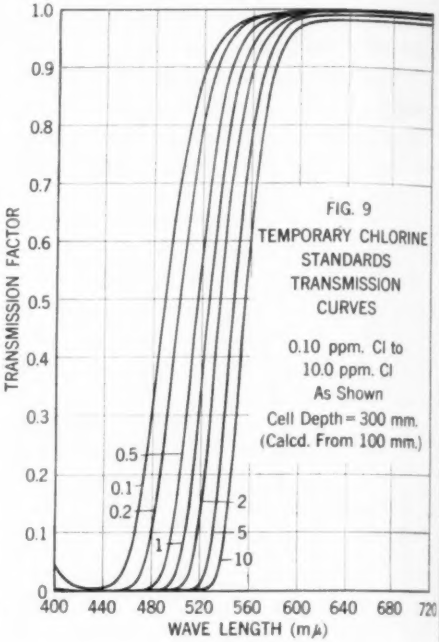


FIG. 9
TEMPORARY CHLORINE STANDARDS TRANSMISSION CURVES
0.10 ppm. Cl to 10.0 ppm. Cl As Shown
Cell Depth = 300 mm. (Calcd. From 100 mm.)

TABLE 2

Monochromatic Color Values of Temporary Chlorine Standards

Chlorine	Trichromatic Values			Purity	Dominant Wave Length	Relative Brightness
	Red	Green	Blue			
ppm.	%	%	%	%	*mμ*	%
For 26-mm. Cell Depth						
0.1	33.34	35.84	30.82	17.5	570	98.6
1.0	42.29	49.18	8.53	77	572	92.3
10.0	49.53	49.64	0.83	98	578	75.8
For 300-mm. Cell Depth						
0.1	42.90	49.60	7.50	80	572	91.1
1.0	50.00	49.23	0.77	98	578.5	73.9
10.0	57.12	42.77	0.11	100	589.5	48.5

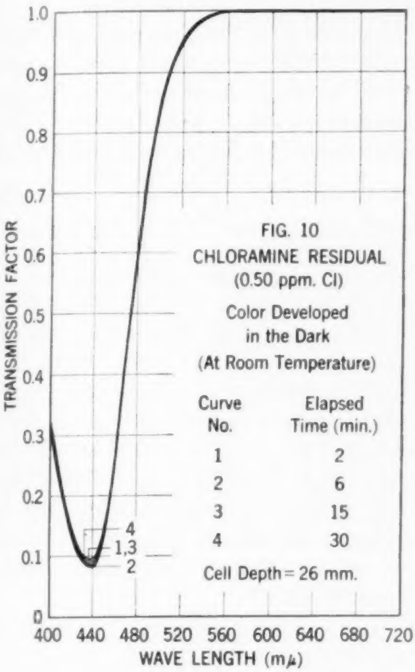
ues, are given in the supporting data on effect of acidity (p. 1069 *ff.*).

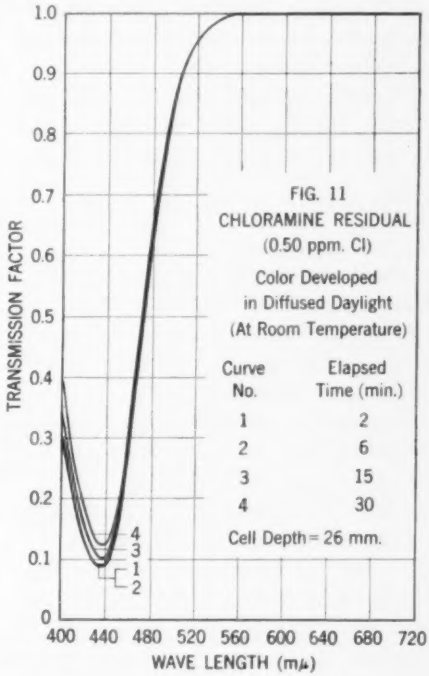
Comparison of Standards With Samples

The development of an ortho-tolidine-chlorine color in a sample should be similar to that in a temporary chlorine standard; and, in a sense, the sample should be considered as a temporary chlorine standard. One aim of this study has been to formulate a procedure favorable to procuring more reproducible results in the samples under adverse conditions.

As pointed out above, the interference of alkalinity and small quantities of iron and nitrites is minimized by using the recommended procedure. Among other differences between the temporary standards and samples are chloramines and temperature. Due to presence of 7.5 times as much acidity in the sample as with the *Standard Methods* procedure for chlorine residuals up to 1.0 ppm., the effect of these interfering factors on the color development will be altered.

If the sample contains chloramines, the color development is not quite as rapid. In Figs. 10 and 11 are shown the effect of chloramines on color development in the dark and in diffused daylight at room temperatures. In either case maximum color development took 2 to 6 min., but, thereafter, the one in the daylight faded the fastest, although not as perceptibly as with a color developed from free chlorine. Since both chloramines and free chlorine give full color development in 2 to 6 min., there is no need to extend the time of reading beyond this period. In the case of cold samples it is rec-





ommended that the samples be warmed immediately after their addition to the ortho-tolidine. When this is not possible the increased acidity of the recommended procedure will aid in more rapid color development.

In using the temporary chlorine standards for comparison, the sample volumes and cell depths must be kept consistent. A fixed rule is that the viewing depths of the temporary standard and sample to be matched *must* be identical. The chlorine molecules, or color molecules equivalent to them, per unit volume must be kept constant.

If samples smaller than the 100 ml. are used, the quantities of reagent and chlorine water must remain proportional. If 15-ml. cells are used, 0.75 ml. of ortho-tolidine should be placed in the cell and chlorine water added to the 15-ml. mark. For 10-ml. cells, 0.50 ml. of ortho-tolidine should be used. These cell depths usually afford good mixing.

If a comparator cell or tube is of such great depth as to make constant mixing impossible, as in the case of Nessler tubes, the chlorine water should be added to the ortho-tolidine with constant mixing in another vessel and then transferred to the comparator cell or tube. Tubes or vessels used for samples, as well as those used for temporary standards, should be kept filled with chlorinated water when not in use.

Summary

A uniform procedure for the preparation of quantitative and reproducible ortho-tolidine-chlorine colors for residuals up to 10.0 ppm., in standards and samples, has been presented.

The procedure requires that the following conditions be fulfilled in the final color mixture:

1. That the ratio of ortho-tolidine to chlorine be at least 3 : 1 by weight
2. That the ratio of acid to ortho-tolidine be at least 100 ml. of concentrated hydrochloric acid per gram of ortho-tolidine
3. That the pH be between 0.3 and 1.3
4. That it be prepared by the addition of the chlorine water to the ortho-tolidine reagent with continuous mixing.

To fulfill these conditions for potable waters containing alkalinity not in excess of 1000 ppm. as calcium carbonate, it is recommended: (1) that the water be added to the ortho-tolidine reagent under favorable mixing conditions at the rate of 100 ml. per 5 ml. of ortho-tolidine reagent; and (2) that the reagent contain 150 ml. concentrated hydrochloric acid per liter and 1.0 g. ortho-tolidine per liter. This reagent may be more conveniently prepared by using 1.35 g. ortho-tolidine dihydrochloride in place of 1.0 g. ortho-tolidine. For waters of greater alkalinity and sewage, the use of an increased amount of ortho-tolidine reagent is recommended.

Use of the recommended procedure has other beneficial results:

1. More rapid color formation, especially with chloramines
2. Increased stability of the color
3. A color that obeys Beer's law up to 1.5 ppm. and deviates from Beer's law at a uniform rate for residuals from 1.5 to 10.0 ppm.
4. Less interference due to iron
5. Less interference due to nitrites.

The use of the recommended procedure does not alter the interference due to manganese.

Acknowledgment

The authors gratefully acknowledge the aid rendered by Dr. M. G. Mellon and R. E. Kitson of Purdue University, Lafayette, Ind., and W. F. Little and Miss J. B. Fuller of the Electrical Testing Laboratories, Inc., New York, in obtaining the records of several hundred spectrophotometric curves; the advice and assistance of G. M. Booth and A. E. Griffin of Wallace & Tiernan Co., Inc., Newark, N.J., and Dr. H. C. Marks of Wallace & Tiernan Products, Inc., Newark, N.J.; and the suggestions of C. K. Calvert, Chairman, A.W.W.A. Committee on Control of Chlorination.

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Experimental Treatment Plant at Miami

By A. B. DeWolf

THE primary object in building and operating the Miami experimental pilot plant was to discover new methods of water treatment which could be adapted to the existing water works. Miami's present water supply is derived from fifteen wells, located in three fields. The largest group (eight) is on the Municipal Golf Course, about a mile south of the plant. The second group (four) is about a quarter of a mile southwest of the plant and the smallest group (three) is within the plant grounds.

All the wells penetrate the same type of aquifer, a highly permeable formation, consisting of sandy limestone and calcareous sandstone (recently tentatively named "Tamiami Limestone" by the local office of the U.S. Geological Survey). This formation is interwoven with innumerable small channels, which accounts for its high permeability.

The wells vary in depth from 60 to about 120 ft. and average approximately 75 ft. Water stands in the well casings to within a few feet of the ground surface. A horizontal centrifugal pump, which discharges into a manifold leading to the treatment plant, is provided for each well.

The physical characteristics of the raw water are approximately as follows: color, 60 to 100; odor, faintly sulfuretted; temperature, 78°F. Chemical characteristics are as shown in Table 1. Very little biological life is

TABLE 1

Chemical Characteristics of Raw and Treated Water

Item	Raw	Treated
pH Value	7.1	9.2
	ppm.	*ppm.*
Total Dissolved Solids	353	174
Color	60	18
Hydrogen Sulfide (H_2S)	1.2	0
Alkalinity (as $CaCO_3$)	217	36
Carbonate Hardness (as $CaCO_3$)	217	36
Noncarbonate Hardness (as $CaCO_3$)	49	52
Total Hardness (as $CaCO_3$)	266	88
Silica (SiO_2)	8.9	9.2
Iron (Fe)	0.9	0
Calcium (Ca)	96	28
Magnesium (Mg)	7.1	4.4
Sodium and Potassium (by difference as Na)	25	11
Carbonate (CO_3)	0	2
Bicarbonate (HCO_3)	264	41
Sulfate (SO_4)	37	38
Chloride (Cl)	45	27

A paper presented on November 13, 1942, at the Florida Section Meeting, Miami, Fla., by A. B. DeWolf, Capt., Corps of Engrs., U.S. Engr. Office, Jacksonville, Fla. The work described in the paper was performed by the author in his capacity as Mech. Engr., Dept. of Water & Sewers, Miami. The pilot plant is under the consulting supervision of A. P. Black, Cons. Chem. Engr. to the Dept. of Water & Sewers, Miami.

found in the raw water, although one of the wells in the second field occasionally shows a high plate count, with an occasional portion fermenting brilliant green bile broth. This well is located near a recently abandoned cow pasture.

Treatment Problems

The treatment applied at the plant consists of aeration, addition of lime and alum for removal of carbonate hardness, chloramination, stabilization with carbon dioxide and filtration. The lime softening process removes practically all of the dissolved iron and brings about a material reduction in color. Table 1 gives the results of analysis of a typical sample of the treated water.

It will be noted that the treated water is satisfactory in all respects except color. Although, to the layman, the color is not noticeable in a drinking glass, it is very noticeable in a bathtub and gives an unpleasant appearance in swimming pools. The high color is also a source of trouble to ice plants and laundries.

In addition to too much color, the present supply contains sufficient organic matter to produce unpleasant tastes when the water is chlorinated; and, although the hardness is not excessive, it is somewhat higher than the usually accepted optimum value.

During the past seventeen years, the transmission and distribution mains have accumulated a deposit of soft ripply slime, which, due to the roughness of its surface, has greatly reduced the flow coefficient. Up to the present time, the cause of this deposit has not been established and considerable research is required to discover how to prevent further deposits and, if possible, how to remove the existing slime without mechanical cleaning.

Investigation of New Supplies

In addition to working out new treatment methods for the well water, it seems advisable to make similar studies in connection with possible future sources of supply. Two such sources immediately present themselves for consideration—the Miami Canal and Lake Okeechobee. Of these the canal is the more accessible.

Characteristics of the raw water from the Miami Canal are shown in the following summary of results of a typical sample analysis:

	ppm
Color (aerated)	130
Chlorides (as Cl^-)	18
Alkalinity (as $CaCO_3$)	224
Calcium (as Ca^{++})	94
Calcium Hardness	235
Magnesium (as Mg^{++})	6.3
Magnesium Hardness	26
Carbonate Hardness	224
Noncarbonate Hardness	37
Total Hardness	261

Upstream from the plant, the canal receives a small amount of pollution, which could, however, be abated easily. At present the coliform index is approximately 240 and the algae load is low most of the time, as the flow in the canal is good.

Enough water from this source has been treated at the main plant to demonstrate that, with the process now employed, a water much inferior, in some respects, to the effluent now obtained with well water would be produced. Although hardness would probably be lower, color would be considerably higher and tastes and odors would be objectionable. Also, despite the fact that it would be satisfactory

biologically, it is feared that many complaints would arise from consumers if canal water were to be processed in the plant, notwithstanding the improbability that any water-borne disease would result.

Lake Okeechobee water has been successfully treated in a number of instances and would undoubtedly make a good supply, but, as the lake is 75 miles from the water plant and at nearly the same elevation, the cost of constructing supply lines would be so great as to make it worthy of consideration only after nearby possibilities had been exhausted.

Although the treatment plant has a well equipped laboratory and although the results of experiments carried out therein have shown that it is possible to overcome all of the objectionable features of water from both the wells and the canal, many laboratory methods are either not readily adaptable to the plant or are too costly. Also, after the experience in treating canal water, it seemed hardly proper to continue to use a 40-mgd. plant for experimental purposes and the citizens of seven or eight municipalities as guinea pigs.

Pilot Plant Design

Since the main reason for building the pilot plant was to use it for exploring new methods of water treatment, which could be adapted to the existing water works, it was designed, not to produce an ideal arrangement, but rather one which would parallel the existing purification plant as closely as possible. The first drawings, which were an almost exact miniature of the main plant, were discarded because the hydraulics of the scale model would not duplicate that of the large plant. Preliminary drawings were submitted to two manufacturers of water treatment equipment for criticism and their engineers gave valuable assistance in the solution of the problem. In the final design, the proportion of diameter and depth in the pilot plant is quite different from that of the large plant, but mixing facilities, rates of rise and depths of basins correspond closely to those of the prototype.

The first unit (Fig. 1) was placed in operation early in 1942. Later, a "Hydrotreator" was added to the assembly, and more recently an "Accelator" was installed (Fig. 2). The "Hydrotreator" and "Accelerator" are patented processes, but both employ the principle of upward flow through a blanket of precipitated sludge. It is believed both will prove of much value in the experiments. Finally, an experimental ozone generator and absorption tower were also installed, completing the present equipment.

Experimental Work

Up to the present time, the greater part of the experimental work undertaken has been with well water in the original portion of the pilot plant. It has been found that considerable improvement to the softening, now obtained in the main plant, can be effected without the addition of more chemicals; also, that the residual color, after softening, can be reduced to almost any desired value by reliable coagulation methods. Coagulation in the present plant, however, would bring about unsatisfactory operation and would be quite expensive, with filter runs probably only about 15 per cent as long as those now obtained. This method, however, could, if necessary, be used in spite of the difficulties involved.

Break-point chlorination brings about a satisfactory color reduction and is less expensive than coagulation, but involves the risk of producing disagreeable chlorinous after-tastes. The organic matter in the water imparts a faint odor and taste at present and this is accentuated, rather than reduced, by break-point chlorination. Therefore, this method of color reduction does not appear to be suited to the Miami plant.

The use of ozone has also been studied, and, although work along that line is not complete, there is definite promise of favorable results. Experiments indicate that the residual color can be reduced to an acceptable value by the addition of less than 2 ppm. of ozone. Further, this quantity of ozone produces no disagreeable after-taste or odor.

As previously indicated, some work has been done with canal water. The results obtained so far indicate that, while an acceptable, finished water can be produced from this source, the operation problems involved are much more difficult of solution than those connected with well water. Also, the treatment cost involved is likely to be considerably higher. Satisfactory softening could be accomplished with little or no change in plant or operation, but the color of the softened canal water would be much higher than that of the softened well water, and odors and tastes would be pronounced. It is probable that this color, odor and taste could be removed with ozone. Thus, the results of experimental work with the canal water lead to the conclusion that, although it could be treated successfully, its use should be avoided as long as possible.

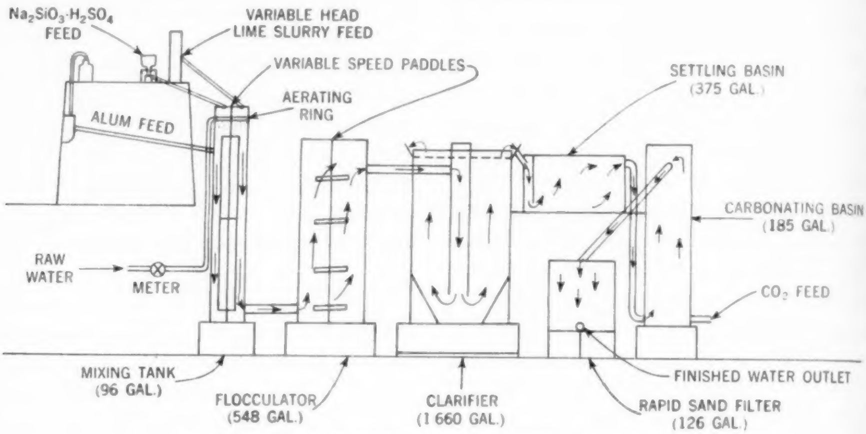

FIG. 1. Pilot Plant Set-up for Single Treatment

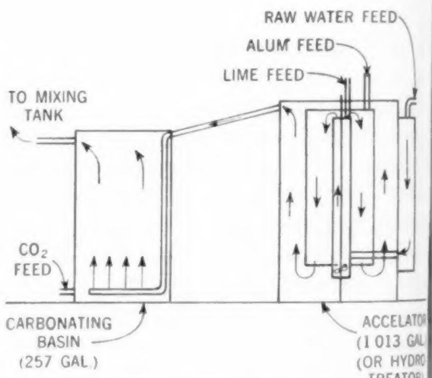

FIG. 2. Pilot Plant Set-up for Double Treatment

Results Achieved

Despite the fact that work with the pilot plant is not completed, enough has been accomplished so that, apparently, the goal is in sight. It is still necessary to determine how the rapid up-flow type of softener can be best fitted into the treatment process. If it is demonstrated that equally good results can be obtained with such equipment, as with the more elaborate machinery now in use, it would be possible to remodel the two existing clarifiers and thereby increase the capacity of the treatment plant by at least 50 per cent, without the addition of further structures. It also appears that the rate of filtration could be increased 50 per cent, provided that the turbidity of the clarified water would not exceed the present value and that the ozonation process is employed prior to filtration. With these two possibilities carried into effect, the capacity of the present purification plant would be increased from 40 to 60 mgd., with only a moderate investment and no increase in the ground space occupied.

The results obtained to date from the operation of the pilot plant support the opinion that the trouble and expense involved in its construction will be repaid many times over by the improvements and economies made possible by its use. It is also indicated that the pilot plant should be made a permanent feature of the water works. Since the science of water treatment is still progressing, the availability of a method of giving each new process a thorough trial on the pilot plant scale before either accepting or rejecting it will be a valuable asset. It is obvious that experimentation on a 40-mgd. scale is far more expensive than on the 10-gpm. rate through the pilot plant. Furthermore, it is wiser policy to test the finished product of a new process on a few selected persons than on a consuming public of as many as 400,000 people.

Recruiting and Training Auxiliaries for Water Works

By Earl Devendorf

RECRUITING and training of water works auxiliaries or volunteer personnel to supplement and assist the regular employees of water departments constitute one of the important objectives of the New York State Mutual Aid Plan. The *Manual of Emergency Sanitation Services,* prepared by the Division of Water Main Emergency Repairs of the State Office of Civilian Protection, which has been widely distributed among water works authorities and local directors of civilian protection for the instruction and use of local health, water, sewer and milk officials and for the information and guidance of chairmen of local war councils, covers the organization, equipment and training of water main emergency repair crews and other auxiliary water works personnel. Since this manual is now available in printed form, it would serve no purpose here to repeat in detail the material covered by it. It does seem desirable, however, for a proper understanding of New York State experiences, to outline briefly the general policy recommended to water works authorities in the recruiting and training of water works auxiliaries.

A contribution by Earl Devendorf, State Water Co-ordinator and Asst. Director, Div. of Sanitation, State Dept. of Health, Albany, N.Y.

General Policy

In the development of the Mutual Aid Plan, it was indicated that each local water authority should be made an active member of the civilian protection organization in each community. Thus it was necessary that local water authorities confer with the chairmen of the local councils and the directors of civilian protection to work out arrangements whereby each community would have an organization in which the local water authorities would be definitely integrated with the civilian protection organization, but directly responsible for the handling of all emergency water supply problems and the training and supervision of all volunteer or other personnel assigned for emergency water duties.

It was pointed out that in order to cope with the emergency breaks in water mains, occurring at several points over a system, which would result in case of bombing, the regular water department organization would be insufficient to cope with the problem and to make repairs promptly and that the regular forces, therefore, should be supplemented with an organization of volunteer reserve personnel. These emergency crews, including the foremen and labor pre-assigned to them, should be instructed as to the stations to which they are to report in the

event of air raid alarm and they should be thoroughly trained in their emergency duties.

It was also pointed out that local plumbers were believed to possess, in general, the best qualifications of any group to work as foremen of emergency water main repair crews. It was recommended that the emergency repair crews and other auxiliary personnel should be given a course of training as outlined in the Manual.

Recruitment of Auxiliary or Volunteer Personnel

In the New York State program the local civilian mobilization representative is responsible for the recruitment and assignment of all volunteer personnel in the civilian protection service. Local water superintendents, therefore, were requested to requisition the desired number of volunteer and auxiliary personnel, having the qualifications prescribed in the Manual, from the local volunteer mobilization representative. In order that such volunteer personnel be covered by compensation in case of emergency, it was pointed out that it is extremely important to have all such volunteer or auxiliary members of the repair crews registered with the local personnel officer of the Citizens Defense Corps.

As stated previously one of the primary objectives of the Mutual Aid Plan for water service has been to secure within each municipality of the State an adequate number of trained water works auxiliaries, who in the event of a serious "incident" will shut off water main breaks, repair broken mains, establish an emergency door-to-door water delivery service, or operate emergency pumping stations and sewage treatment plants. To give impetus and direction to efforts toward this important and urgent objective, and in co-operation with the State Office of War Training, Water Series Bulletin No. 1 entitled "Organization and Training of Water Main Emergency Repair Crews and Auxiliary Personnel Assigned to Emergency Water Service Duties," was prepared and widely distributed (Jour. A.W.W.A., **34**: 803 (1942)). This bulletin which outlines in detail the procedures for the recruitment of volunteer auxiliary personnel, the qualifications of such personnel and the course of training to be given to such auxiliaries, is now available in printed form in our Manual.

Emergency Water Service Training

Following the release of Water Series Bulletin No. 1, there were organized Regional Emergency Water Service Training Schools at five locations in the State. These were conducted for the following purposes:

1. To explain thoroughly the training program for auxiliaries to local water and sewer officials.
2. To explain to local water officials the details of the course of instruction to be given to water works auxiliaries.
3. To give local water and sewer superintendents, upon whom the main burdens of training are imposed, instruction in teaching technics.

To achieve these purposes, there were obtained the active assistance and co-operation of the State Office of War Training, the State Education Department, the Municipal Training Institute, the Mayors' Conference, the Association of Towns, the American Water Works Association, the National Board of Fire Underwriters, the New York State Fire Insurance Rating Organization and the superintendents of many

public water supplies. The course of instruction as outlined was amplified to include complete lesson material upon each subject of the course, prepared in each instance by outstanding experts. This material, originally mimeographed as separate lectures and lesson sheets, was presented at the Regional Emergency Water Service Training Schools to local water officials for their use as a guide in giving instructions on the prescribed lessons of the course to their own auxiliaries. All of this original material is printed in the Manual.

Following the Regional Emergency Water Service Training Schools, many local courses, either on a county-wide or municipal basis were organized by the zone and assistant zone coordinators in co-operation with the local water authorities for the training of water works auxiliaries in the four prescribed classes for emergency water service duties. These courses will be continued until the training program is completed for the state as a whole. It is expected that ultimately about 4000 volunteer auxiliaries will have completed the instruction which is being given in a uniform manner throughout the state and according to the prescribed syllabus of this course. In all these courses the lectures and lesson material printed in Part III of the Manual are being used as guides for instructors in presentation of the instruction to the auxiliaries.

The experience thus far acquired has proved that the course of instruction, as recommended here, is sound and that auxiliaries who satisfactorily complete the course are actually competent to perform their duties in any emergency organization of a water department.

New York State Experience

Some illustrations of the various problems presented in the organization and training of water works auxiliaries in different parts of the state, due to the different conditions existing in various localities will, it is believed, be of interest.

(1) Westchester County is located in the southern part of New York State adjacent to the Metropolitan New York area. It is densely built up with large cities and many important villages. As a result of a survey made by the Zone Co-ordinator for the county, who is also the County Commissioner of Public Works, it was found, according to the various water superintendents' estimates that they needed a total of 12 volunteer foremen, 42 valve operators, 80 supervisors of emergency water delivery service, and 4 auxiliary pumping station operators. The fact that there was a greater demand for emergency water service is probably due to the fact that this is something outside of the usual line of work and most of the superintendents preferred to use their regular crews for the work in which they are best trained.

The survey also showed that the municipalities together have a total of 56 fully equipped and trained repair crews from their regular forces. It was found that by splitting up their regular repair crews and filling in with laborers or other men, regularly in the employ of the water department, the total number of repair crews could be increased to 100. The above, together with the fact that repair crews could be dispatched from one end of the county to the other in 45 min. resulted in the decision of the Zone Co-ordinator that, insofar as Westchester County

was concerned, they did not have the need that undoubtedly exists in most parts of the state for training auxiliary repair crews. They did need, however, a training program for their regular personnel, particularly for water main sterilization and the development of auxiliary shut-off crews.

(2) In the northern part of New York State, adjacent to the Canadian border, the communities are small, widely separated, and the water supply systems are accordingly small, with usually only one man in charge of the system. This is the condition throughout the three counties in the zone, with the exception of two or three larger communities and one city. In this area it has been difficult to obtain any local consideration of augmenting the regular forces of the water departments and we have emphasized the need of essential contacts between the local water supply forces of the various communities for their mutual protection rather than stressing the training of auxiliary forces along the standard pattern.

Courses of instruction were modified to fit the local conditions. The schools are organized on a group rather than a county basis. Under these conditions the instructions were given to larger groups and auxiliaries so that they would know something of the development and sources of adjacent water supplies as well as the supply to which they were directly assigned. It was felt that this would better fit them to co-operate with and assist each other in any emergency.

(3) As an example of a well-planned and excellently executed program for a rural area may be cited the experience in the Oneonta district in the south-central part of the state. In these three counties, the county directors of civilian protection appointed water supply representatives for each county. The Zone Co-ordinator and the water works authorities were, therefore, represented directly in the county defense organizations and this resulted in a closely co-ordinated training program and in maintaining interest among the water superintendents. Here the program of organizing and training of the water works auxiliaries was carried out in some respects in a more satisfactory manner than in other areas in the state in spite of the fact that it is almost exclusively, with two or three exceptions, a rural area with relatively small water systems.

(4) Nassau County, adjacent to the City of New York, includes a large number of important water supplies serving many army and war-connected plants. Under the Commissioner of Public Works of the County, who is also the Zone Co-ordinator, the organization of water works has been developed to a very high degree with a large number of water works auxiliaries who have been exceptionally well organized and trained. The need for such a well trained and generously staffed water works organization is particularly important in view of the many highly important defense-connected plants located in the area and its location adjacent to the sea coast.

(5) One of the most important areas in the state from the standpoint of war production is the Buffalo-Niagara Frontier area where many of the important war industries are located. The city of Niagara Falls is the center of chemical and electrical industries. Seventy-five per cent of the total water supply of the city is served to the industries. In addition the industries pump be-

tween two and three times the total volume of water delivered by the city in separate pumping stations applying water for industrial use. Likewise, many important defense plants are located in and adjacent to the City of Buffalo.

Under the above circumstances, a great deal of effort has been devoted to the organization and training of water works auxiliaries in the area with the result that a very high type of organization has been developed among these communities.

Problems Presented in Organization

Some of the difficulties met, in general, in organizing and carrying out the training program have been due to the following:

With the gas rationing it became necessary to obtain a ruling from the local rationing board with the result that additional gas was furnished to those taking the training course upon certification of the zone and assistant zone water co-ordinators. A good share of the training program was carried on during the winter months which, due to weather conditions prevailing in New York State during this season, makes it difficult for travel. This was overcome in a measure by doubling up on the class lessons, reducing to one-half the number of trips. Classes were held usually for twice the period of time ordinarily scheduled.

Important Points in Planning for Organizing and Training Water Works Auxiliaries

In carrying out and organizing a training program for water works auxiliaries it is important to provide a complete understanding of the need of such water works auxiliaries and their importance. The class lectures are of primary importance both in supplying information to the uninitiated in regard to the various essential features of the work to be assigned to the water works auxiliaries and to provide an incentive and interest in the work. The experience in New York State has indicated almost without exception that those enrolled or having undertaken to attend lectures have been faithful and have missed very few lectures.

Finally, it is of extreme importance to provide a continuing interest among the water works auxiliaries by providing tasks to organized crews, after completion of the training period. The importance of this cannot be overemphasized. The British civilian protection organizations have indicated this to be one of the most difficult as well as very important tasks. With the completion of the training work, if no tasks are assigned, the interest dwindles. It is being urged that, upon completion of the training course, the auxiliaries be assigned to tasks such as checking valve locations, maps, records of auxiliary sources of water supply, co-ordinating the work with local fire authorities, etc.

Of interest is a quotation from "Training Volunteers for Water Emergency Work" by J. McClure Wardle (W.W. Eng., **96**: 59 (1943)):

"It is now our problem to keep these auxiliaries active and enthusiastic for the duration. We are having monthly two-hour meetings, and so far have made out very well by having interesting papers and discussion first, and appropriate movies for the last hour. When the weather warms up we think we will hold these sessions out-doors.

"We have proved to ourselves that auxiliaries can be successfully trained in a short intensive course and we are glad to feel that now we have a volun-

teer force backing us up that would come to our assistance not only for war work but for any emergency. We've seen times when we could use them all."

The New York State Mutual Aid Program has been successful beyond the fondest first hopes and expectations. Its success, in the author's opinion, may be attributed to three principal factors:

First: A well thought-out plan and program was presented to the water authorities of New York State, which met with the whole-hearted support of the New York State War Council and the State Director of Civilian Protection. Several other state and municipal organizations contributed materially to the program.

Second: The water works authorities almost without exception threw themselves and their whole organizations wholeheartedly into the work. It has meant many hours of extra work for these men. The success achieved is principally due to their energy, ability and devotion. From the beginning, Harry Jordan, Executive Secretary of the A.W.W.A., and the officers of the New York State Section of the Association have rendered much valuable assistance to the Mutual Aid Program.

Third: The regional OCD Sanitary Engineer and his office have been of great assistance in making available data and material developed by the other state sanitary engineers and state water co-ordinators and by his personal assistance at lectures and meetings throughout the state.

In the short time available it has been possible only to sketch some of the highlights of the New York State experience. Complete details of the Program are, however, now available in the Manual. Copies have been sent to each of the state sanitary engineers. Additional copies will be made available upon request to the extent that the supply will permit.

War Production Board

Construction Conservation Order L-41

CONSTRUCTION Limitation Order L-41 has been again amended as of July 27, 1943.

The general import of this order is expressed in its paragraph (b)(1) which reads:

"No person shall begin construction, carry on any construction begun in violation of any order in the L-41 series, cause such construction to be begun or carried on or participate in such construction, or order, purchase, accept delivery of, withdraw from inventory or in any other manner secure or use material for such purposes."

A *new section* (b)(2)(vi) reads as follows:

"Facilities other than buildings to be owned by a producer, as defined in Order U-1 (4501.1), pertaining to utilities, or in Order P-141 (3209.1), pertaining to public sanitary sewage facilities, which are to be used directly in providing one or more of the services set forth in paragraph (a)(1) of said Order U-1, or in paragraph (a)(1) of said Order P-141."

This paragraph clearly records the exclusion of water works construction *other than buildings* from the general restrictions of L-41.

Applications for water works construction are filed on Form WPB 2774 which was fully described in the July JOURNAL, pp. 977–80. Forms 2774 are filed with the WPB Office of War Utilities, Washington, D.C.

Applications for sewage works construction are filed on Form 617 (formerly PD-200). These are sent to the WPB Government Div., Washington, D.C.

Priorities Regulation No. 3 Amended

IN the July JOURNAL (p. 977), it was pointed out that paragraph (f)(2) of Priorities Regulation No. 3 as amended June 4, 1943, made it impossible for water utilities to apply the ratings conferred by Order U-1 to their orders for maintenance and repair needs for hydrants. This situation has now been rectified.

Amendment No. 3 to P.R. No. 3, issued August 10, excludes hydrants from the restricted list of items which cannot be ordered on maintenance and repair authority. Thus, this amendment clears the way for water utilities to place orders for hydrants and hydrant parts under the authority and rating conferred by U-1.

The instant that the subject was brought to the attention of the staff of the Office of War Utilities (OWU), every effort was brought to bear to get the restrictions against hydrant production voided, as the measure adversely affected the application of U-1. At the time that the Controlled Materials Plan was initiated, the OWU filed an estimate of requirements of controlled materials—*hydrants included*. The delay occasioned by the earlier restriction has been against the desire of, and beyond the responsibility of, the OWU.

American Water Works Association

Tentative Standardization Procedure

(Approved by the A.W.W.A. Board of Directors, June 18, 1943, as tentative)

1. General Policy

1.1 The Board of Directors, as the body of elected representatives of the Association's membership, is responsible for (1) approval of the initiation of all standardization activities by any group organized to act for the Association; and (2) approval of all specifications or related documents prepared by any committee of Association Members.

1.2 The Committee on Water Works Practice is organized under the terms of Article IX Section 2 of the By-Laws:

"A Committee on Water Works Practice shall be appointed by the Board at the annual convention. It shall consist of at least five members, at large, and its Chairman shall be ex-officio a member of the Board.

"Any resolution, report or publication which undertakes to establish in the name of the Association, or any of its Sections or Divisions, professional or technical standards, shall be submitted to this Committee, and it shall direct all such matters on behalf of the Association.

"It shall give notice by publication to the membership of all such proposed standards and report its approval or disapproval of such to the Board.

"It shall appoint such Subcommittees as it may deem necessary to carry on its work properly."

1.3 The Committee on Water Works Practice may organize subcommittees to develop specifications, recommended practice documents or manuals of procedure covering any phase of water supply activity. It shall periodically report to the Board of Directors the status of all subcommittee work. Specifications or manuals prepared by subcommittees and approved by the Committee on Water Works Practice shall be submitted to the Board of Directors for approval before they are published as Association documents.

1.4 Any organized Division of the Association may, in regular meeting, recommend the organization of committees to develop specifications, recommended practice documents or manuals related to the field of interest of the Division. Such recommendations, including a definition of the scope of the proposed activity, shall be approved by the Committee on Water Works Practice before work is in-

itiated. The personnel of such committees shall be reported to the Committee on Water Works Practice and approved by it.

1.4.1 When a Divisional subcommittee has completed its study, its report shall be approved by the Division in regular session or by letter ballot of the Executive Committee of the Division before it is submitted to the Committee on Water Works Practice and to the Board of Directors for approval as an Association document.

1.5 The Secretary of the Association shall act as the Secretary of the Committee on Water Works Practice.

2. Definition of Terms

2.1 The term "Tentative Standard" shall be applied to those specifications, methods, and definitions that have been approved by the sponsoring committee and accepted by the Association in accordance with the procedure established therefor, for publication and use preliminary to adoption as standard, thus providing opportunity for suggestion, and criticism.

2.2 The term "Standard" shall be applied collectively to standard specifications, standard methods, and standard definitions that have been approved by the sponsoring committee and adopted by the Board in accordance with the procedure established therefor.

2.3 The terms "Recommended Practice" or "Manual" shall be applied to procedures, processes and methods not ordinarily subject to contract between purchaser and manufacturer.

3. Procedure Governing the Adoption of Standards, Recommended Practice Documents or Manuals

3.1 The procedure governing the promulgation of standards shall be as follows:

3.1.1 Acceptance of tentative standards, tentative revisions of standards, and revisions of tentative standards, and withdrawal of standards, tentative standards, and tentative revisions of standards, shall be either by action of the Board of Directors as provided in Paragraphs 3.1.2 and 3.1.3 or of the Committee on Water Works Practice as provided in Paragraph 3.1.4. Adoption of Standards or related documents shall be either by action of the Board of Directors in regular meeting or by letter ballot.

3.1.2 An affirmative vote, amounting to two thirds of the Board Members voting at a stated meeting, shall be required on all committee recommendations, except those involving immediate adoption of standards and immediate revision of standards. (For procedure on these exceptions see Paragraph 3.1.3.) These committee recommendations may be amended by an affirmative vote amounting to two-thirds of those voting, subject to approval of the revised recommendation by letter ballot of the committee; however, if the revised recommendation is rejected by the committee, the original committee recommendation shall be considered as approved by the Board and the proposed revision shall be referred to the committee for study and report at the next meeting of the Board. Committee recommendations submitted to the Board for approval by letter ballot must obtain an affirmative vote of eight-tenths of the Board Members before their approval.

3.1.3 If immediate adoption as standard is recommended, either of a proposed new standard or of a revision of an existing standard, without the usual preliminary publication as tentative, a nine-tenths rather than a two-thirds affirmative vote of Board members present and voting shall be required. In this case no amendment during the meeting shall be permitted, except with unanimous consent.

3.1.4 Committee recommendations on acceptance of tentative standards, tentative revisions of standards, and revisions of tentative standards, and on withdrawal of standards, tentative standards, and tentative revisions of standards, may also be presented between annual meetings to the Committee on Water Works Practice for consideration and approval. The Committee on Water Works Practice shall determine whether the requirements of the Association relating to committee procedure have been met and whether the committee has reached a satisfactory consensus. During consideration of the recommendation of a standing committee, representatives of the committee may be present and participate in the discussion. If the Committee on Water Works Practice takes favorable action upon the recommendation, the document shall be submitted to the Board for its approval by letter ballot.

3.2 The requirements of Sec. 3.1 shall be applicable also in the establishment of recommended practice documents or manuals of procedure.

3.3 Reports, resolutions and recommendations pertaining to or involving the use, or proposed use, in a standard or tentative standard, of any device or process which forms the subject matter of any existing patent, copyright or trade-mark, shall first be submitted to the Committee on Water Works Practice, and shall be submitted to the Board of Directors only with the approval of the Committee on Water Works Practice.

3.4 All specifications, recommended practice documents and/or manuals of procedure shall (except as provided in 3.1.3) be termed tentative when first approved by the Board. They shall, if no modifications are proposed, be termed "standard" after a period of one year. The Board of Directors shall at its stated meetings take due note of the status of tentative standards and may by two-thirds affirmative vote suspend for a stated or an indefinite period the designation of any document as "standard."

3.5 For the duration of the war, the following emergency policy is approved:

3.5.1 A special subcommittee consisting of the Chairman and Vice-Chairman of the Committee on Water Works Practice and the Secretary is authorized to consider revisions, or modifications of existing specifications or preparation of new specifications to meet conditions set up by the war emergency.

3.5.2 When the content of the text has been agreed upon by the three members of the subcommittee, the material shall be submitted by letter-ballot to the Committee on Water Works Practice and to the Board of Directors.

3.5.3 A period of two weeks shall be allowed for the filing of objections to, or acceptance of, the specifications. If a consensus of opinion develops, the material shall be issued either as (1) tentative A.W.W.A. specifications, (2) emergency specifications, or (3) an emergency wartime rider to existing specifications.

3.6 Standards or related documents prepared by joint or inter-association

committees upon which the American Water Works Association has appointed a representative and for which the Association acts as co-sponsor, shall be approved by the Committee on Water Works Practice and by the Board of Directors in the manner stipulated for A.W.W.A. documents in 3.1, 3.2, 3.3 above.

3.7 Standards or related documents prepared by a committee of other associations to which committee the A.W.W.A. has been invited and to which it has appointed one or more representatives, shall not be subject to the approval routine of the A.W.W.A. Representatives upon such committees shall be appointed by the Committee on Water Works Practice and may be withdrawn from the activity at any time for cause satisfactory to the Chairman of the Committee on Water Works Practice. Such representatives shall report the activities and progress of their work to the Committee on Water Works Practice not less often than once each year. They may at any time refer to the Chairman and/or Secretary of the Committee on Water Works Practice for advice concerning, or assistance related to, the work of the committee to which they have been appointed.

CONSTITUTION AND BY-LAWS OF THE AMERICAN WATER WORKS ASSOCIATION

(Adopted June 25, 1929, with amendments to September 1, 1938, and further proposed amendments herewith)

CONSTITUTION

ARTICLE I

Name

The name of this Association shall be—The American Water Works Association.

(Constitution)

ARTICLE II

The object of this Association shall be the advancement of knowledge of the design, construction, operation and management of water works, and its membership shall consist of persons interested in such matters, having such qualifications and classifications as shall be from time to time prescribed in the By-Laws.

(Constitution)

ARTICLE III

BOARD OF DIRECTORS

SECTION 1. The Governing Body of the Association shall be a Board of Directors, hereinafter called the Board.

SECTION 2. The Board shall consist of:

a. The President of the Association.

b. The Vice-President of the Association.

c. The Treasurer of the Association.

d. One Director to be elected by each Section of the Association.

e. Three Directors to be elected by the Water *and Sewage* Works Manufacturers Association.

f. The latest living Past President of the Association.

g. The Chairman of the Committee on Water Works Practice.

h. The Chairman of the Publication Committee.

SECTION 3. The terms of Directors and Officers shall start at the begin-

ning of the last day of the annual convention *held subsequent to the date of their election. If, for any reason, a Director is not elected until after the date of the holding of the annual convention at which he should have commenced his term of office, his term of office shall begin at the date that the advice of his election is received by the Secretary. The terms of Directors and Officers shall terminate at the beginning of the last day of the annual convention in the year of expiration of their terms of office.*

If, for any reason, the annual convention of the Association is not held between January 1, and July 1, in any year, then the terms of newly elected Directors and Officers shall commence on July 1, of such year; and the terms of office of the Directors and Officers who are to be succeeded shall terminate on that date.

SECTION 4. The President of the Association, the Vice-President of the Association and the Directors elected by the Sections of the Association and by the Water *and Sewage* Works Manufacturers Association will not be eligible for reëlection for consecutive terms.

SECTION 5. The Officers of the Association shall be the Officers of the Board.

SECTION 6. The functions of the Board shall include the following:

a. Establishing policies for the Association, and for the Executive Committee, and for the Officers.

b. Providing for the general administration of the affairs and property of the Association.

c. Fixing the time and place of the annual and other conventions of the Association as provided in the By-Laws.

d. Preparing and enforcing for the conduct of the business of the Association, By-Laws not in conflict with this Constitution, and amending the same.

Section 7. The Board may exercise the above described functions either in session at stated or duly called meetings or by letter ballot. Any matter that requires action by the Board of Directors at a time not conveniently related to a regular or called meeting may be submitted to it for approval by letter ballot.

The Board may, by resolution, designate categories of Association business which may be submitted to it by letter ballot. Matters not thus designated may be considered by the Executive Committee in the exercise of its stated duties (By-Laws, Article IV), or the Executive Committee may refer such matters to the Board for approval by letter ballot. Such action by the Executive Committee may be taken either at a meeting of the committee or by a letter ballot of the committee, if the initiation of said letter ballot is directed by the President in a letter addressed to the Secretary. Except as otherwise provided by resolution of the Board, matters submitted to it by letter ballot shall obtain an affirmative recorded vote of two-thirds of the Board membership to secure approval. The results of all letter ballots shall be reported to the Board at its next meeting.

SECTION 8. A quorum of the Board shall consist of a majority of its members.

SECTION 9. Regular meetings of the Board shall be held during the annual convention of the Association, on such days as may be decided by the Board. Other meetings may be held at the direction of the President, or at the re-

quest, in writing, of five members of the Board, and on such notice as shall be provided in the By-Laws.

Section 10. No Board Member may be represented in any action required of him as a Board Member by any other person; nor may he vote, by letter, upon any matter scheduled for consideration at a duly called meeting of the Board.

(*Constitution*)

ARTICLE IV

Nomination and Election of Officers and Directors

SECTION 1. There shall be a meeting of the Board held in January of each year at which a Nominating Committee consisting of the Directors representing the various Sections of the Association shall meet under the Chairmanship of the President, and shall nominate one, and may nominate two candidates for each of the offices of President, Vice-President, and Treasurer, provided that any candidate so nominated shall be an Active Member of the Association, and shall have been a member of the Executive Committee prior to the adoption of the present Constitution and By-Laws, or a member of the Board of Directors since its adoption, and shall signify willingness to accept the nomination. This Committee shall report its list of nominees to the Board before the close of its January meeting, and the list shall then be mailed to the membership before February first of that year.

At any time prior to noon on the first day of March of each year additional nominations may be made by request to the Secretary, signed by at least twenty-five Active Members, and upon receipt of such request, the Secretary shall, after acceptance of the nomination by the candidates, add such names to the ballot prepared by him. The nominees of the Nominating Committee shall be so designated on the ballot for each office, and the names of all nominees shall be arranged in alphabetical order.

When more than one name is nominated for either office, the election shall be by letter ballot. Each Active Member shall be entitled to vote for one candidate for the office of President, one candidate for the office of Vice-President, and one candidate for the office of Treasurer. The ballot shall be prepared by the Secretary and mailed to each Active Member of the Association prior to April first in each year, and shall state the name and residence of each candidate.

The ballot shall be sealed separately in a special ballot envelope, and the latter shall be enclosed in a larger envelope, and mailed to the Secretary. The signature of the member voting shall appear on the outer envelope.

When a letter ballot is necessary, the Secretary together with two or more Tellers appointed by the President shall meet at a time and place directed by the President, and shall open and count all ballots cast by persons entitled to vote. No ballot shall be counted if received later than noon of the seventh day previous to the beginning of the annual convention of the Association. When only one candidate is placed in nomination for each office to be filled, the report of the Nominat-

ing Committee shall be considered as an election.

The report of the Tellers for the election of the incoming President, Vice-President, and Treasurer shall be declared by the President at the annual convention on certificates of the Tellers. The candidates who shall have received the highest number of votes cast for the several offices shall be declared elected. If there be a tie vote the President shall order a ballot to be taken at the annual convention to decide which of the candidates who have received the same number of ballots shall be chosen.

SECTION 2. The terms of the Officers so elected shall *commence at the beginning of the last day of the annual convention, following the date of their election; and shall cease at the beginning of the last day of the next annual convention. But, if an annual convention is not held prior to July 1, that date will be the date of the beginning of the term of office of an officer. Said term shall be for approximately one year, but shall continue until a successor has been chosen.*

In case of a vacancy in the office of President, the Vice-President shall act in his place for the unexpired term. In case the Vice-President cannot act, the latest living Past President shall do so.

In the case of a vacancy in the office of Treasurer, the Executive Committee shall appoint an Active Member to fill the office for the unexpired term.

SECTION 3. One Director to represent each Local Section shall be nominated and elected by the members of the Section at an annual Section meeting, and in the same manner as the Presiding Officer of that Section is elected. The manner of such election shall receive the approval of the Board. The Director so elected shall be an Active Member and shall reside in the territory of the Section at the time of his election. Should he cease to reside in the territory of the Section before his term of office is ended, it shall be within the power of the Section to replace him.

The term of each Director so elected shall be for *approximately three years, beginning with the last day of the annual convention immediately following his election, or on the following July 1. When a new local Section is established, the initial term of the Director representing such Section shall be as determined by the Board.*

In the case of the retiring, from any cause, of a Director representing a Section, before his term is completed, the governing body of the Section shall designate his successor, who shall serve for the unexpired portion of the term.

SECTION 4. Three Directors shall be nominated and elected by the Water *and Sewage* Works Manufacturers Association. The term of each Director shall be for three years beginning with the last day of the annual convention immediately following his election, *or on the following July 1.*

In the case of the retiring, from any cause, of a Director representing the Water *and Sewage* Works Manufacturers Association before his term is completed, the governing body of the Water *and Sewage* Works Manufacturers Association shall designate his successor who shall serve for the unexpired portion of the term.

(*Constitution*)

ARTICLE V

Amendments

Proposals to amend this Constitution shall be submitted in writing to the Board, signed by at least ten Active Members of the Association.

The Board shall consider the proposals, and the proposers shall be notified of the Board's opinion in regard thereto not later than the first day of March.

The proposers may then withdraw their proposals, accept any change suggested, or insist on the original form, sending their decision to the Secretary not later than the first day of April.

The proposals, as accepted by the proposers, shall be mailed to the Active Members not less than twenty-one days before the annual convention.

Proposals to amend this Constitution may also be made by the Board and shall be mailed to the Active Members not less than twenty-one days before the annual convention.

All proposals shall be submitted for discussion at the annual convention.

The Active Members there present may propose an amendment or amendments thereto, and all proposals together with any such amendment or amendments shall be printed on a letter ballot to be submitted to the Active membership.

The Secretary shall issue the letter ballot not later than two months after the annual convention.

On the written request of three or more members the letter ballot shall be accompanied by a statement giving reasons for and against the proposal edited by a Committee appointed by the Board, consisting of an equal number of members favoring and members opposing the proposal.

The letter ballot shall be returnable to the Secretary not later than three months after the annual convention. Three Tellers appointed by the Board shall forthwith count the ballots and report the result to the Board.

An affirmative two-thirds of all valid ballots shall be necessary for the amendment or repeal of any part of the Constitution.

The amendments as passed shall take effect at the beginning of the next calendar year except that changes affecting the tenure of office of an Officer of the Association shall not take effect until the next annual convention.

BY-LAWS

ARTICLE I

Membership

SECTION 1. The membership of the Association shall consist of Honorary, Active, Corporate, Associate, Junior Members and Affiliates.

SECTION 2. An Honorary Member shall be one whose practical or scientific knowledge in matters relating to water supply, and whose accomplishments in that field of endeavor shall entitle him to special recognition by the Association. Honorary Members shall have the same privileges as Active Members but shall not be required to pay any dues for the support of the Association.

SECTION 3. An Active Member shall be a superintendent, a manager, an official or employee of a municipal or private water works; a civil, mechanical, hydraulic, or sanitary engineer, a chemist, a bacteriologist, or any qualified person engaged or interested in the advancement of knowledge relating to water supplies.

SECTION 4. A Corporate Member shall be a Water Board, Water Commission, Water Department, Water Company or Corporation, National, State or District Board of Health, or other body, corporation or organization engaged or interested in water supply work, and shall be entitled to one representative whose name shall appear on the roll of members and who shall have all the rights and privileges of an Active Member. This representative may be changed at the convenience and pleasure of the Corporate Member on written notice to the Secretary.

SECTION 5. An Associate Member shall be either a person, firm or corporation engaged in manufacturing or furnishing supplies for the operation, construction, or maintenance of water works.

SECTION 6. A Junior Member shall be an employee of a municipal or private water works; a civil, mechanical, hydraulic, or sanitary engineer, a chemist, a bacteriologist, a student or any otherwise qualified person engaged or interested in the advancement of knowledge relating to water supplies. At the time of his admission he shall be not less than eighteen years of age. His connection with the Association shall cease when he becomes twenty-five years of age, unless he is regularly enrolled as a student in a university or has previously transferred to the grade of Active Member. Junior Members shall receive the Journal and all privileges of Active membership except holding office and voting.

SECTION 7. An Affiliate shall be any person otherwise qualified for Active membership who, at the time of application, is not nor previously has been a member of the Association, and who, for acceptable reasons, does not wish to become an Active Member.

No corporation, firm or partnership which otherwise would be entitled to the grades of Associate or Corporate Member may hold the grade of Affiliate. No employee of an Associate Member may become an Affiliate. No person who is the Superintendent, the Manager, the Chief Engineer, the Superintendent of Filtration, the Chief Chemist or the Superintendent of Distribution in a plant having more than 3000

active services, is eligible for the grade of Affiliate. Under unusual conditions, exception to the above may be made by action of the Executive Committee if the applicant sets forth fully the reasons for the exception when applying for the Affiliate grade.

Affiliates shall not be entitled to vote upon general Association questions, and not eligible to hold office in the Association, nor in any of its Divisions. They shall be eligible to vote upon Section questions and to hold Section offices except those of Chairman, Vice-Chairman, Secretary (and/or Treasurer). They shall be entitled to all other rights and privileges of Active Members.

(By-Laws)

ARTICLE II

Admission and Expulsion

SECTION 1. The Board, on its own initiative, or at the request of twenty-five members of the Association, may elect any qualified person an Honorary Member. This election shall take place at a regular meeting of the Board and shall be by ballot. Two negative ballots shall exclude.

Each Honorary Member shall receive an engrossed certificate of membership in that grade.

SECTION 2. Applications for Active, Corporate, Associate, or Junior membership and for the Affiliate grade shall be made on the blank forms provided by the Association. Each application shall embody a concise statement of the applicant's qualification for membership. All applications shall be forwarded to the Secretary who shall submit them to the Board.

An affirmative vote of a majority of the Board shall elect and the applicant shall become a member when his annual dues shall have been paid.

Affiliates may transfer to the grade of Active Member by application therefor and upon approval of the Secretary.

SECTION 3. No member whose dues are in arrears for four months shall receive the publications of the Association until such arrears are paid. Members in arrears for one year shall be automatically dropped by the Secretary from the list of members.

SECTION 4. The Board may, for sufficient cause, temporarily or permanently excuse from the payment of annual dues, any member who from ill health, advanced age, or other good reason, is unable to pay such dues, and the Board may remit the whole or part of dues in arrears, or accept in lieu thereof desirable additions to the library or collections.

SECTION 5. A member who has been dropped for nonpayment of dues may be reinstated by the Board on payment of the arrears. He shall then be entitled to receive such back numbers of the publications of the Association as may have been withheld from him on account of nonpayment of dues, and are available for distribution.

SECTION 6. Any member of any grade may be expelled from membership in the Association, by a three-quarters vote of the Board, taken by letter ballot, provided such member has been given a written statement of the charges preferred, and has been accorded an opportunity of a hearing before the Board.

SECTION 7. Any member may retire from membership by giving written notice to the Secretary, provided that he is in good standing.

(By-Laws)

ARTICLE III

Fees and Dues

SECTION 1. Each Active Member shall pay annual dues of ten dollars, provided that any Active Member in good standing who has paid dues continuously for thirty years shall be exempt from payment of further dues. No initiation fee shall be required from a member in good standing of an Affiliate Association or Society, who has been elected as an Active Member.

SECTION 2. Each Corporate Member shall pay annual dues of fifteen dollars.

SECTION 3. Each Associate Member shall pay annual dues of twenty-five dollars.

SECTION 4. Each Junior Member shall pay annual dues of five dollars.

SECTION 5. Each Affiliate shall pay annual dues of four dollars.

SECTION 6. The fiscal year of the Association shall begin on January first, and terminate on December thirty-first. Annual dues shall be payable in advance, and shall be due on January first in each year. It shall be the duty of the Secretary to notify each member on or before December thirty-first in each year of the amount due from said member for the ensuing year.

SECTION 7. Any newly elected member shall be entitled to all of the publications of the Association that are distributed to its members during the year, or that part of the year, for which he has paid dues.

Affiliates shall receive all publications to which the members are entitled except that they shall receive four issues only of the JOURNAL per year.

(By-Laws)

ARTICLE IV

Executive Committee

There shall be an Executive Committee of five members consisting of the President and four Directors. This Committee shall be chosen by the Board at its meeting at the annual convention.

The President of the Association shall act as Chairman of the Committee, or in his absence, the Committee shall choose a temporary Chairman from its members, and the Secretary of the Association shall act as its Secretary.

The duties of the Committee shall be to direct the administrative work of the Association and to carry out the policies of the Board between meetings of the latter.

A quorum of the Committee shall consist of three members.

(By-Laws)

ARTICLE V

Duties of Officers and Directors

SECTION 1. The President shall have general supervision of the affairs of the Association, and shall preside at all conventions of the Association and meetings of the Board. In his absence he shall designate a Presiding Officer to act in his stead at such conventions or meetings. He shall be, ex-officio, a member of all Committees.

SECTION 2. The Vice-President shall assist the President in the performance of his duties, and act in his

stead when required. He shall be, ex-officio, a member of all Committees.

SECTION 3. The Board of Directors shall be the legal representatives of the Association, and as such shall have full control of the Association in regular convention. It shall make the necessary arrangements for the conventions, and shall have power to expend the funds of the Association, or to invest the same, but must not incur indebtedness beyond the funds in the hands of the Treasurer and Secretary. It shall hold a meeting during the last day, and also a meeting at least one hour before the opening session of each annual convention. Other meetings shall be held at the call of the President, or of any five members of the Board. Notice of all meetings shall be issued by the Secretary at least ten days in advance of such meetings to all members of the Board.

At the meeting on the last day of the convention, the Board shall appoint the Secretary, who shall serve until the close of the next annual convention or until his successor shall have been appointed. If no annual convention is held prior to July 1, in any calendar year, the incoming Board of Directors shall appoint the Secretary as soon after July 1 as may be found feasible by said Board.

Except as otherwise provided in the Constitution and By-Laws, all questions before the Board shall be decided by a majority vote.

SECTION 4. The Treasurer shall have charge of the funds of the Association and shall pay bills against the Association when *signed* by himself and the Secretary. He shall make *such reports to the Board as may be necessary or as may be called for by said Board.* He may, with the approval of the Board, establish a drawing account for the Secretary.

He shall be bonded at the expense of the Association, and to an amount to be determined by the Board.

He shall perform such other duties as may be assigned to him by the Board.

SECTION 5. The Secretary shall be an Active Member of the Association. It shall be his duty to attend all conventions and meetings of the Association, and of the Board, prepare the business and duly record the proceedings thereof. He shall see that all moneys due the Association are collected, and shall promptly deposit the same to the credit of the Association. He shall certify to all bills against the Association, and once each month he shall forward to each member of the Board, a financial summary of receipts and disbursements.

The Secretary shall have charge of the printing and distribution to all the members of the Proceedings and Transactions of the Association.

He shall be ex-officio, a member and Secretary of the Committee on Water Works Practice and of the Publication Committee.

He shall make such reports to the Board as may be necessary or may be called for by the Board.

He shall have charge of the books and records of the Association and shall supervise the work of all employees.

The books of the Association shall be audited annually by Certified Public Accountants, to be appointed by the Board.

He shall be bonded at the expense of the Association, and to an amount to be determined by the Board.

He shall perform such other duties as shall be assigned to him by the Board.

Section 6. If an Editor is appointed by the Board, he shall perform such

duties as shall be assigned to him by the Board. He shall be, ex-officio, a member of such committees as may be designated by the Board.

(*By-Laws*)

ARTICLE VI

Conventions of the Association

The annual convention of the Association shall be held at a time and place to be selected by the Board. Additional conventions of the Association may be held at such times and places as may be selected by the Board. Meetings of the Sections shall be held as determined by the Constitutions of the Sections. All conventions and meetings shall be conducted according to "Roberts Rules of Order."

Each member and guest present at any of the conventions of the Association shall pay a registration fee of such amount as may be determined by the Board.

(*By-Laws*)

ARTICLE VII

Sections and Divisions

SECTION 1. Local Sections may be established by the Board on receipt of a written request to that effect signed by twenty Active or Corporate Members of the Association residing in the territory within which the Local Section is desired. The territory embraced by each Local Section shall be fixed by the Board.

SECTION 2. National Divisions consisting of superintendents, engineers, chemists, bacteriologists, and accountants or other classes of persons included in the membership of the Association may be established by the Board on the request of thirty members. Any member of the Association may register in any National Division of the Association in which he is interested.

SECTION 3. Such Local Sections and National Divisions which shall consist only of members of this Association in good standing shall elect their own Officers and Committees, and may make any rules for their government not inconsistent with the Constitution and By-Laws of the Association, but these rules must first be approved by the Board.

SECTION 4. Each Local Section as soon as established, and after its rules have been approved by the Board, may with its approval annually receive from the Treasurer of the Association for local use not more than twenty-five per cent of the annual dues paid to the Association by the members of the said Local Section as shown by the books of the Association on the first day of November of each year, unless the Board increases the amount allowed to any Local Section, the amount of such increase to be determined by the Board and to be allowed only when in the judgment of the Board the work undertaken by that Local Section is such as to be of material benefit to the Association. Unless the Board increases the amount allowed the total money received by any Local Section for any one fiscal year shall not exceed the sum of $300. Local Sections having small membership shall be entitled to receive from the Association $100 i

any one fiscal year, even though the allotted twenty-five per cent of the annual dues paid to the Association by the members of the said Local Section does not amount to $100.

Each National Division when established and its rules and Constitution have been approved by the Board, may with the approval of the Board, annually receive from the Treasurer of the Association a sum not exceeding $100 for Division expenses.

The Treasurer of each Local Section or National Division shall forward to the Secretary of the Association his application endorsed by the Presiding Officer of the Section or Division for such portions of the said sums above specified as may be needed and upon receipt of such application the Secretary shall authorize the Treasurer of the Association to pay such sums to the Treasurer of the Section or Division. These moneys may be used by the Section or Division only in payment of necessary operating expenses.

At the end of each fiscal year the Treasurer of each Section and Division shall submit a certified copy of his accounts to the Secretary of the Association, the same being itemized and showing the balance on hand of funds received from the Association which will remain to the credit of such Section or Division until such Section or Division is dissolved or the Board shall otherwise order their return to the treasury of the Association.

SECTION 5. Any member of the Association who resides in a locality which is not included in the territory embraced by an existing Local Section, may upon written request to the Board be included in the membership of any Local Section. The Secretary of the Association shall notify the Secretary of the Local Section of the enrollment of the member.

Whenever a new Local Section is formed or an existing Local Section has its territory extended which will include in its territory the locality where such member resides, he shall automatically be included in the membership of such Local Section.

SECTION 6. Any Section or Division may be dissolved by the Board for reasons which it believes are good and sufficient.

(*By-Laws*)

ARTICLE VIII

Publications

All publications of the Association shall be issued under the direction of the Board and shall be copyrighted as far as is practicable and proper.

(*By-Laws*)

ARTICLE IX

Committees

SECTION 1. A Publication Committee shall be appointed by the Board at the annual convention of the Association. It shall consist of at least five members, at large, and its Chairman shall be ex-officio a member of the Board.

It shall have control of the publications of the Association, including the programs of its conventions and shall

see that all publications and papers are edited before publication.

The Committee shall prepare rules which shall govern the preparation, presentation, acceptance, and publication of all papers and such other matters of a similar nature as the best interests of the Association may require.

SECTION 2. A Committee on Water Works Practice shall be appointed by the Board at the annual convention. It shall consist of at least five members, at large, and its Chairman shall be ex-officio a member of the Board.

Any resolution, report or publication which undertakes to establish in the name of the Association, or any of its Sections or Divisions, professional or technical standards, shall be submitted to this Committee, and it shall direct all such matters on behalf of the Association.

It shall give notice by publication to the membership of all such proposed standards and report its approval or disapproval of such to the Board.

It shall appoint such Subcommittees as it may deem necessary to carry on its work properly.

SECTION 3. The Board shall appoint such other Committees as may be necessary to carry on the work of the Association.

(*By-Laws*)

ARTICLE X

Board of Directors

The Board of Directors may amend these By-Laws in any manner not inconsistent with the Constitution by a two-thirds vote of those voting at any meeting of the Board or by sealed letter ballot, providing that a copy of such proposed amendment has been mailed by the Secretary to each member of the Board at least thirty days prior to such meeting or letter ballot.

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British); I.M.—Institute of Metals (British).*

U.S. WATER SUPPLIES—GENERAL

Water Supply Engineering. *Report of the Committee of the Sanitary Engineering Division for the Three Years Ending December 31, 1942.* Proc. A.S.C.E. **69:** 399 (Mar. '43). Past 3 yr. ('40–'42) witnessed gradual tapering off of govt.-subsidized constr. for civilian purposes and substitution of expenditure for war. Consumption went on rapidly in period, being 40%–90% greater in '42 than in '39 or '40. Production of reinforced concrete pipe during past yr. far in excess of former years. Mfrs. of asbestos-cement pipe working at top output during '42. New type of asbestos-cement pipe mfd. by extruding fairly stiff mortar contg. asbestos. Process of lining pipe in place, using traveling centrifugal mortar-applying machine with revolving troweling attachment continued in field. Am. branch office promoting Australian process of applying cement lining to small pipe in place continues to do considerable business. Salient features of priorities control are: (1) All projects require submission of applications to WPB. (2) Materials for maintg. utilities may be obtained or used if available in stock. (3) Authorization to obtain material to repair breakdowns in pumps and other equip. can be obtained by telephone or wire request. (4) Material for water supply connections to authorized projects can be obtained by use of priorities which attach to such projects. (5) Inventories of water supply material on hand filed periodically with WPB. (6) WPB may and often does change kind of material requested to some other kind less needed at time for war purposes. Handling of applications by WPB becoming more prompt and skillful; also, no. of civilian projects diminishing and new methods of material allotment in view. Notable civilian water supply projects include: Grand Coulee Dam; Lake Mead and Boulder Dam; Central Valley Project, embracing Shasta Dam, Keswick Dam, Friant Reservoir and system of canals; Metropolitan Water Dist. of S. Calif.; Mono Basin Supply; Delaware-Rondout Water Supply for N.Y.C.; Metropolitan Dist. of Boston; Baltimore Water Tunnel; Indianapolis impounding reservoir, 16-mgd. unit of filter plant, etc; Toledo water supply work costing about 10 million dollars; and Harrisburg, Pa., constructed upland supply not filtered. Numerous cantonments and military posts built at scattered points throughout world and old ones enlarged. War Dept. supplied following data for its stations:

Stations using purchased water	334
Stations having some type of water supply plant	710
Stations having filtration and treatment plants	91
Filtration and treatment plants	144
Estd. water usage at all stations, as min. (*mgd.*)	500
Total capac. of filter plants (*mgd.*)	191
Water main, max. 30″ id. (*mi.*)	6608
Service pipe (*mi.*)	2680
Civilian personnel assigned to maint. and operation of water supply systems (no enlisted men employed), approx.	3000

Telegram dated Dec. 8, '41 sent by U.S. Surgeon General to state depts. of health

urged water works officials: (1) to take immediate steps against sabotage; (2) to provide guards at danger points; and (3) to step up chlorine dosage to provide residual throughout distr. system. Request not generally complied with because of disagreeable effect on qual. of water and feeling that it is not necessary. Much study based on English experience given to water supply problems in war previous to this time by water works assns. These studies included: prevention of sabotage; contamn. by poison or disease germs; decontamn.; precautions in prepn. for bombing attacks; camouflage; protection of dams; and design of dams. Severe drought occurred in northeasterly part of U.S. during '41 and early part of '42. Rainfall deficiencies in '41 from 11" to 27" in Mass. and Conn. Various parts of country experienced floods of record intensity during past 3 yr. Tendency to make spillways more liberal continues as records of large floods added. Not cheerful thought that many existing dams bound to go out with lapse of time as storms of high intensity chance to hit valleys in which they lie. Adage of hydr. engr. of high repute to "make spillways as big as Lord will let you" seems to be good rule. War has not materially affected water purif. except to prevent constr. of needed improvements in few cities. Tendency toward higher chlorination of water not been stopped entirely. Addn. of ammonia for partial dechlorination of water following addn. of high dosage of chlorine being given some consideration. Use of sodium hexametaphosphate for corrosion prevention increasing. Notable census of water treatment plants in U.S. made by U.S.P.H.S. (*see* Jour. A.W.W.A. **34:** 1585 ('42)). A.W.W.A. Committee on Survival and Retirement of Water Works Facilities made noteworthy progress report of statistical data on life history of c-i. pipelines, valves, hydrants and meters, (*see* Jour. A.W.W.A. **34:** 1831 ('42)).—*H. E. Babbitt.*

Ingenuity in Modern Water Works Design. Paul E. Langdon. Am. City **58:** 3: 60 (Mar. '43). Addns. to their water supply system required by water activities at Portsmouth, Va., include aerators, reaction basins, sedimentation basins, rapid sand filters, 2 reservoirs and force mains. Designed to save max. of critical materials reinforcing steel cut 85% and c-i. pipe cut about 60% by using mass concrete in division and outside walls and floors and unreinforced concrete pipe imbedded in mass concrete of structures. Distr. of raw water by stop logs. Reservoirs of gravity wall sections and groined-arch roofs and floors, all unreinforced.—*F. J. Maier.*

Annual Report, 1941, Department of Water Supply, Detroit, Mich. Report for fiscal yr. ending June 30, '41. Dept. operates under bd. of water comrs. Revenues for yr. showed appreciable increase over previous yr. due to (in order): increased demands of industry, suburban sales, commercial consumers. Operating expense increases, however, exceeded revenue increase, due entirely to sewage disposal charges for filter wash water which increased from $56,451 to $338,129. Water sales equaled $7,848,984, with total operating revenue of $7,939,862, increase of $223,054 over '40. Total operating expenses $2,992,131, as against $2,712,188 in '40. Interest on bonds and bond amortization equaled $2,712,043, provision for debt retirement was $1,886,533 (stated as "in lieu of depn."), leaving net income of $401,918, increase of $150,033 over '40. Property, plant and equip. is given in assets as $121,367,936; bonds payable, $65,028,738. Prin. asset items are:

Boiler plant equip.	$1,160,272
Steam power pumpg. equip.	1,604,320
Purif. equip.	1,344,575
Elec. power pumpg. equip.	2,797,284
Pumpg. sta. lands	1,579,558
Supply source structures	3,673,013
Pumpg. sta. structures	7,756,398
Purif. structures	3,696,480
Reservoirs	1,950,809
Gen. office structures	1,591,667
Transmission mains	16,241,461
Distr. mains	57,909,098
Services	6,195,483
Consumers' meters	3,081,798

In period '22–'23, revenue dollar divided: (1) wages, 37¢; (2) debt charges, 33¢; (3) replacements and improvements, 16¢; and (4) operation and maint., 14¢. Same items in '40–'41 were: (1) 20¢; (2) 57¢; (3) 9¢; (4) 14¢. Total number of accts. 305,015, three prin. classes being domestic (270,073) with consumption of 27.24% of pumpage, commercial (24,700) with 18.36% and suburban (7,337) with 14.66%. Munic., unmetered, and unaccounted-for water consumed 10.31% of pumpage. Of 12,979,537,500 cu.ft. of total

pumpage, 81.56% revenue-producing; avg. revenue per 1000 cu.ft. of revenue-producing pumpage 74.0¢; avg. revenue per 1000 cu.ft. of total pumpage 60.4¢. Among larger suburban cities served are: Dearborn (pop. 63,584), Hamtramck (50,160), North Woodward (34,613), Ferndale (25,654). Total pop. served 1,997,685, 1,670,000 of which in Detroit. The 372,820 services are 99+% metered; increase in current yr. of 10,864 meters brought total meters, ⅝″ to 24″ in size, to 305,406. Net gain in services equaled 12,382. Avg. cost of testing 34,600 ⅝″ meters 7.1¢ each; 5,022 ¾″ meters 8.4¢ each; and 1280 1″ meters 22¢ each. Avg. cost of installing ⅝″ meter this yr. $8.53, of which $8.06 represented avg. material cost and $0.47 avg. cost of labor and cartage. Same avg. installation figures for ¾″ meters were $12.43, $11.88 and $0.55; and for 1″ meters $18.38, $17.59 and $0.79. Total of 1720 meters repaired, total avg. repair cost of ⅝″ equaled $1.84, made up of $0.54 materials cost and $1.30 labor costs. Same figures for ¾″ meters $2.19, $0.89 and $1.30; for 1″ meters $3.32, $1.76 and $1.56. 5406 meters damaged by hot water and 16,948 by wear and tear. 9 regular 4-man crews kept busy making repairs to main and service leaks these repaired 309 broken mains, 293 leaking joints and 1108 service leaks. Garage maintd. 114 automobiles, 2 tractors, 2 air compressors and 18 trailers; repair work being done by 4 repairmen. Total mileage of mains in the distr. system given as 2933.78 mi. in Detroit, 1840.43 mi. in suburban area, with grand total of 4774.21 mi. 11,123,902′ of 6″ and 8,540,079′ of 8″ represent largest individual sizes; range extends from 4″ to 72″. During yr. 17,194′ of 30″ and 5593′ of 24″ cleaned by machine and 244′ of 30″ and 34′ of 24″ by hand. System contains 58.76 mi. of steel pipe and 4.171 mi. of asbestos-cement pipe. Net gain in system mileage (all pipe) in yr. was 68.936 mi. No. of public fire hydrants 27,573. Consumption of water during yr. 4.76% greater than preceding yr. with 7 mo. of yr. showing increases over corresponding mo. of 4.8 to 18.6%. All-time pumping high reached on June 27, '41, with 417.5 mgd. Temp. of day 95°F. and preceded by 10 days of practically zero pptn. Total pumpage for yr. 97,093 mil.gal.; corresponds to per capita consumption of 133 gpd. Avg. consumption for yr. 266 mgd. Water taken from Detroit R., treated and pumped at 2 main stations—Water Works Park Sta. and Springwells Sta. Operation data for 2 stations as follows:

Item	*Water Works Park*	*Spring-wells*
Avg. low-lift head, *ft*	21.11	46.65
Avg. high-lift head, *ft*	—	75.43
Avg. operating eff., %	67.81	75.43
Water evapd. per lb. of coal (actual), *lb*	8.615	10.30
Overall eff. of boiler plant, %	65.88	—
Thermal eff. of pumping plant, %	—	17.46
Coal required to raise 1 mil.gal. 100′, *lb*	848.29	445.49
Water delivered to mains per lb. of coal as fired, *gal*	—	980.13
No. of filter units	80	68
Total rated filter capac., *mgd*	320	40
Avg. filter run, *hr*	43.4	38.4
Avg. wash water, %	2.94	4.30
Coagulation and sedimentation:		
Capac., *mil.gal*	29	24
Avg. depth, *ft*	16	18
Retention time, *hr*	2	3
Avg. alum used, *tons/day*	4.98	3.75
Avg. alum dose, *lb./mil.gal*	67.6	57.3
Avg. chlorine used, *lb./day*	472	465
Raw water turbidity, *ppm*	3–136	1–120
Avg. chem. results (effluent):		
Turbidity, *ppm*	0.3	0
Residual chlorine, *ppm*	0.15	0.16
CO_2, *ppm*	2.2	2.4
pH	7.7	7.6
Alky., *ppm*	82.9	79.9
Total hardness, *ppm*	96	—
M.P.N. index of coliform bacteria per 100 ml:		
Raw water	79	41.6
Tap water	0	0

Ammonium sulfate and powd. activated carbon used intermittently. Research being carried on with different types of surface wash, in odor detection and evaln. and in bact. media. Rpt. has many graphs and tables with considerably more information than included here, all readily available.—*Martin E. Flentje.*

Prospecting for Water in a City of Oil Wells. E. W. DeBerard. Am. City **58:** 4: 66 (Apr. '43). When oil wells constructed within 20′ of shoreline of Lake Centralia, water supply reservoir for Centralia, Ill., city decided new source desirable. In addn., drainage area and storage capac. inadequate; wood pipeline and steam pumping plant outmoded and inefficient. New supply obtained from impounding Raccoon Creek with drainage area of 48.5 sq.mi. New low service pumping station at dam; steam plant replaced by elec. high-lift pumping station with gasoline engine standby. Changes in filter plant involved extensions to sedimentation basins, flash mixers, mech. coagulators, addnl. dry feed and chlorine machines and larger sized filter sand. Former filter runs of 11 to 14 hr. extended to 48 hr. Considerable difficulty in obtaining material, some of which not yet delivered.—*F. J. Maier.*

CANADIAN WATER SUPPLIES—GENERAL

Annual Report, Chatham, Ont., 1942. ANON. W.W. Inf. Exch.—Can. Sec. A.W. W.A. **5:** E: 14: 21 (Feb. '43). Consumption 2.55 mgd., equivalent to 127 gpd. per capita. Cost of water per 1000 gal. 8.94¢ and revenue 13.53¢. Alum, ammonium sulfate and Cl used in purif. process. Turbidity of raw water as high as 2400 ppm. Pop. 20,000. Distr. system includes 45.7 mi. mains, 4664 services, 271 hydrants and 4800 meters. Accts. rendered quarterly.—*R. E. Thompson.*

Annual Report, Guelph, Ont., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** E: 7: 12 (Dec. '42). Avg. consumption by 22,973 pop. 3.77 mgd. (161 gpd. per capita). Supply derived from springs (67%) and wells (33%) and treated by chlorination. Cost of pumping water, exclusive of debentures, $12.70 per mil.gal., made up of: pumping labor $4.25; coal $0.29; oil, waste, supplies $0.35; gasoline $0.31; elec. power $5.36; purif. $0.31; deep-well maint. $0.16; pump repairs $1.67. Distr. system consists of 54.1 mi. mains, 270 hydrants, 703 valves and 205 meters.—*R. E. Thompson.*

Development of the Hamilton, Ont., Water Works System. W. L. MCFAUL. Eng. Cont. Rec. **56:** 14: 44 (Apr. 7, '43). Detailed history of Hamilton system since its inception in 1857. Works, completed in 1859, acquired by city in 1861. Original source infiltration basin on shore of Lake Ontario. Although direct connection cut through to lake in 1870–71 and another basin and intakes installed in subsequent yrs., basins not abandoned until '27 when 60″ intake extending 3000′ into lake, revolving screens and chlorination equip. installed. In '33, 37-mgd. filter plant consisting of sedimentation basin, 12 filters and clear water reservoir placed in operation. Consumption in '42 about 24 mgd. Approx. $10,000,000 invested in system and debt at end of '41, $3,297,242.—*R. E. Thompson.*

Annual Report, Ottawa, Ont., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** E: 10: 15 (Dec. '42). Avg. consumption by 173,855 pop. 19.31 mgd., equiv. to 111.1 gpd. per capita. Avg. chem. dosages used in purif. of Ottawa R. water: alum 2.46 gpg., lime 0.77 gpg., Cl 3.39 lb. per mil.gal. Activated C also employed. Avg. rate of filtration 65.27 mgd. per acre, length of filter runs 74.88 hr., and wash water 1.65%. Distr. system consists of 204 mi. mains, 1629 hydrants, 2538 valves, 32,902 services and 2380 meters. Hydrant inspections totaled 70,000, 2747 hydrants being heated and pumped. 132 cases of frozen services. Total revenue $939,449.83 and total expenditures $935,444.88.—*R. E. Thompson.*

Annual Report, Owen Sound, Ont., 1942. ANON. W.W. Inf. Exch.—Can. Sec. A.W. W.A. **5:** E: 13: 20 (Feb. '43). Data given from rpt. of Pub. Util. Com. City, which has pop. of 14,000, has 2 gravity water supplies, 1 from river and 1 from springs. Avg. consumption 2.24 mgd. or 160 gpd. per capita. Operating cost per 1000 gal. 2.4¢ and revenue 3.6¢, leaving net profit of 1.2¢.—*R. E. Thompson.*

Annual Report, St. Marys, Ont., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W. W.A. **5:** E: 9: 14 (Dec. '42). Pop. supplied 4000. Revenue per capita $4.62 and operating costs $4.44. Approx. ⅔ revenue derived from consumers and ⅓ from fire protection charges. Assets totaled $183,323.55 or $45.83 per capita.—*R. E. Thompson.*

Annual Report, Welland, Ont., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W. W.A. **5:** E: 8: 13 (Dec. '42). Water obtained from Welland Canal and purified by filtration and chlorination. Avg. dosage alum used 1.06 gpg. and Cl 0.615 ppm. Carbon, lime, NH_3 and SO_2 also employed. Pop. supplied 18,453, 5615 residing outside city limits. Total water pumped into distr. system 1130.5 mil.gal.; consumption per capita, exclusive of industrial and commercial use, 96.7 gpd. Cost of supplying water per 1000 gal., 5.03¢, including purif. and pumping 1.46, distr. 0.50, admin. 0.80, debt charges 2.15, bldgs. and grounds 0.12. Total cost $56,835.55 and total revenue $82,171.44. 26.1 mi. mains, 287 hydrants, 4670 services and 60 meters.—*R. E. Thompson.*

Annual Report, Dorval, Que., 1942. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** E: 12: 18 (Jan. '43). Dorval, with pop. of 3000, derives supply from Lake St. Louis

(Ottawa R.). Rapid sand filtration and chlorination plant has capac. of 1.5 mgd. (U.S.). Avg. consumption 0.685 mgd. or 215 gpd. per capita. Avg. no. of persons supplied per service 4.83. Filter runs varied from 30–55 hr. and avgd. 36. Alum used avgd. 2.08 gpg., lime 2.3 gpg. and Cl 0.4 ppm. Avg. water bill $17.74, or $3.66 per capita. Color of raw water varied from 40–95 and avgd. 60; that of filtered water 7 to 12, with avg. of 10. Turbidity of raw water varied from 10–30 ppm. and avgd. 13; and of filtered water 2–5, with avg. of 3. pH value before and after treatment 6.7 and 7.6, resp. Cost of water $80.10 per mil.gal., made up as follows: power $16.73, alum $6.10, Cl $0.44, lime $0.29, filter plant maint. $0.81, filter plant wages $17.26, filter washing $4.10, sinking fund and interest $33.16, service maint. $1.30. Revenue avgd. $69.00 per mil. gal., and deficit $0.92 per capita. 82 hydrants and 10 mi. of 4–12" mains. No charge made for fire protection. Since Aug. '42, anthrafilt employed in 2 of 4 filters.—*R. E. Thompson.*

Annual Report, Malartic, Que., 1941. Anon. W.W. Inf. Exch.—Can. Sec. A.W. W.A. **5**: E: 11: 17 (Dec. '42). Supply derived from Malartic R. coagulated, filtered and chlorinated. Pop. supplied 3200 and per capita consumption 54 gpd. Distr. system includes 5 mi. mains, 60 hydrants and 16 valves. Expenditures $12,190.65 and revenue $15,371.03. Details of water rates included.—*R. E. Thompson.*

FOREIGN WATER SUPPLIES—GENERAL

Annual Report of the Board of Directors of the National Department of Sanitary Works, Argentina, 1940. During '40, utilities operated by Dept. of San. Works served water to 4,102,895 persons, maintd. sewerage facilities for 3,044,269 and supplied elec. energy to 78,635. Figures indicate that fed. utilities supplied water to 32% of nation's pop. and operated sewerage systems serving 22% of inhabitants. Execution of Dept.'s constr. program for year, involved expenditure of close to 45.5 million pesos. Of these, 33.7 million spent on water supply and sewerage projects in Buenos Aires metropolitan area and 11.8 million for work done in provinces and territories. At end of year, Buenos Aires Dist. showed net operating profit of 8,131,775 pesos while dists. of interior showed loss of 8,689,760 pesos. Net operating loss of fed. utilities amtd. to 557,985 pesos. Plan designed to place govt.-owned utilities on self-supporting basis being drafted by Dept.'s Board of Directors. To increase admin. eff., Bur. of Studies, Projects and Industries created. New bureau will control no. of divs. formerly attached to Tech. Bur. of Fed. Capital (Buenos Aires Dist.) even though their services were intended to satisfy needs of provinces and territories as well as those of fed. capital. Under new organization, matters pertaining to operation of utilities in Buenos Aires area will be handled by Tech. Bur. of Fed. Capital; those connected with operation of all other fed. utilities will come under Tech. Bur. of Provinces and Territories; while all matters pertaining to prelim. studies and designs for water supply and sewerage projects, operation of industries and auxiliary services will be handled by Bur. of Studies, Projects and Industries. During '40, sulfuric acid plant produced 21,189 tons of 70% H_2SO_4 at cost of 47.94 pesos per ton. Most of this acid used in mfg. aluminum sulfate. New plant for concn. of sulfuric acid from 70–90% H_2SO_4, placed in operation in July, produced 480 tons of concd. acid. Coagulant plant mfd. solid aluminum sulfate only. Of plant output, 29,618 tons sent to Palermo (Buenos Aires) treatment plant and 2750 tons shipped to dists. of interior. Production and delivery costs varied from 78.21 to 81.57 pesos per ton of coagulant with 18% aluminum oxide content. As in past years, Div. of Labs. held responsible for qual. of water served to consumers. Also investigated water qual. of new sources and made chem. and phys. examns. of materials purchased by Dept. To intensify anal. work close to sources of supply, thus obtaining better water qual. control, resolved to establish several labs. in provinces and authorized immediate constr. of 2 of them. Baylis turbidimeter adopted for measurement of turbidities below 1.0 ppm. Bentonite suspensions centrifuged at 2000 rpm. (time not stated) found to give more stable turbidity stds. than those prepd. with fullers' earth. Glass electrode potentiometers adopted for pH detns. Diphenylthiocarbazone (dithizone) method for detn. of lead found more sensitive and direct than sulfide procedure

previously used. Investigation of boron content of water made using Wilcox potentiometric method. Highest boron concn. observed 2.9 ppm. Montequi and Gallego procedure for vanadium (*see* Jour. A.W.W.A., **33:** 1006 ('41)) proved useful for direct detn. of element in waters contg. over 0.05 ppm. Studies also made on methods for removing fluoride from water, detn. of softening properties of natural and artificial zeolites, comparative studies to det. effectiveness of local and imported bentonites as coagulation aids and expts. to det. stability of hypochlorite solns. Special survey on toxic substances indicated that of 184 sources examd., 9% showed fluoride concns. between 1.4 and 2.1 ppm.; 32% of sources contained vanadium in concns. from 0.05–0.5 ppm. although only in 1 instance was higher concn. noticed, and only in 7% of sources was concn. greater than 0.1 ppm. Arsenic found in concns. from 0.01–0.25 ppm. in 50% of sources. Only 2% of sources showed arsenic concns. higher than 0.1 ppm. Max. arsenic and vanadium concns. found in samples taken from infiltration gallery in Bell Ville Dist. Cases of chronic poisoning reported from this dist. (*see* Jour. A.W.W.A. **30:** 1427 ('38)). Although detn. of coliform index std. procedure for appraisal of bact. qual. of water, data on presence of *Clostridium perfringens* proved of value when dealing with totally unknown waters. For this purpose, ferrous sulfite media of Wilson and Blair, incubated at 45°C., proved most satisfactory. Sodium tetrathionate-brilliant green (1 : 130,000) liq. media of Kauffmann-Mueller found superior to other enrichment media tested for detection of organisms of *Salmonella* group. Fecal streptococci found of value as indicators of recent contamn. These organisms detected in 100-ml. aliquots when using sodium tellurite in concns. of 1 to 15,000. Some attention paid to organisms of genera *Pseudomonas* because of their possible significance as causative agents of epidemic gastroenteritis. Other activities of lab. included expts. to det. methods of cement testing suitable for incorporation in portland cement specifications, research on structural steel and pipeline corrosion by water and soil action, studies on effect of hydrogen sulfide on concrete and, investigation of effectiveness of pipeline coating materials. La Plata R. water pumped to Palermo water treatment plant, which serves 2.5 million inhabitants in Buenos Aires metropolitan area, had avg. turbidity of 60 ppm. with max. of 740 min. of 15. Color avgd. 35 ppm. Oxygen consumed fluctuated between 8 and 10 ppm. although occasionally raised as high as 18 ppm. Total solids varied from 85 to 220 ppm., chlorides from 17 to 38 ppm., pH from 7.8 to 8.0 and alky. from 30 to 127 ppm. Aerobic bact. count ranged from 300 to 300,000 per ml. Coliform organisms fluctuated between 200 and 35,000 per ml. No plankton difficulties experienced in river. River water treated with aluminum sulfate applied to suction side of pumps. Doses varied from 49 to 139 ppm. Turbidity of settled water fluctuated between 1 and 3 ppm. although occasionally was as high as 10 ppm. Color of settled water avgd. 4 ppm. Coagulation and sedimentation elimd. from 95 to 98% of bact. content of raw water. Algae, developing during warmer months in settled water collecting channels and on slow sand filters, controlled by treatment with 2 ppm. copper sulfate until disappearance of organisms. Copper treatment followed by chlorination (5 ppm.) to prevent bact. flare-ups as result of accumulation of destroyed plankton on filters. Settled water treated with lime prior to entering filters to reduce CO_2 concn. Avg. lime dosage 22 ppm. As result of treatment, no evidence of dissolved lead in water which had been circulated through lead pipes in system. Turbidity of filtered water avgd. 0.3 ppm. Water chlorinated prior to filtration and at plant outlet. Avg. dose for prefiltered water 0.37 ppm. Post-chlorination ranged from 0.05 to 0.15 ppm., avgd. 0.1 ppm. Bact. qual. of water in distr. system easily met U.S. Public Health Service Stds. which are also the stds. in Argentina. Phys. characteristics of treated water as follows: Color, 4–6 ppm.; turbidity, 0.1–1.0 ppm.; and odor, well under control. Div. of Sewers reorganized to take care of ever-increasing no. of sewerage and sewage disposal projects. Activities of this Div. included adoption of std. methods of sewage anal., gathering of basic anal. data for sewage treatment plant design and study of industrial wastes to recommend, whenever necessary, adequate treatment prior to discharge of wastes into sewers. This section also took over La Plata R. poln. studies and control of disinfection of sewage discharged into water courses tributary to river in vicinity of Palermo treatment plant intake. Rpt. contains great deal of valuable statistical information covering diversified activities of Dept.—*J. M. Sanchis.*

Transfer to the Nation of Water Works in the Districts of Avellaneda, Lomas de Zamora and Almirante Brown. ANON. Bol. Obras Sanit. Nación (Arg.) **7:** 660 (Feb. '43). Report of official act at which Natl. Sanit. Wks. Dept. acquired water supply facilities owned in Avellaneda, Lomas de Zamora and Almirante Brown Dists. by Government of Buenos Aires Province and by Buenos Aires Water Works Co., Ltd. Utilities purchased for $11,749,330 m/n (Argentinan pesos) payable in four equal annual installments, first one due at time transfer of utilities made. Contract stipulates that net income to be used in amortization and payment of interest on purchase money and on future expenditures for improvements and service extensions. After cost of utilities canceled, net profits distributed annually among water-using municipalities in districts. Operation and maint. of acquired utilities subject to Natl. Sanit. Wks. Dept. rules and regulations.—*J. M. Sanchis.*

Sanitary Improvements for the City of Curuzú-Cuatiá, Argentina. ORESTES J. P. CANTALUPPI. Bol. Obras Sanit. Nación (Arg.) **6:** 430 (Dec. '42). City of 7000 pop. bounded by Curuzú-Cuatiá Creek in northeast and by Castillo creek in southwest. Neither stream suitable for domestic supply because of scant summer flows and poor qual. Exploratory work indicated underground water of good qual. in northwest. To satisfy 300-liter per capita per day demand, necessary to sink 5 wells to depths of 50 m. Estd. yield of wells 250 cu.m. per hr. Pumping equip. will be operated by diesel engines. Chlorinators and Venturi meter provided for max. flow of 240, min. of 30 and avg. of 180 cu.m. per hr., under head of 25 m. Elevated tank supported by braced columns 20 m. high will provide storage for 500 cu.m. Distr. system will consists of 32 km. of asbestos-cement pipe, varying in id. from 0.125 to 0.050 m. Plans provide for 1200 service connections ranging in size from 0.032 to 0.013 m. id., 60 fire hydrants and 18 public fountains.—*J. M. Sanchis.*

Water Supply Facilities for Town of Suncho Corral, Argentina. DANIEL A. BRUNELLA. Bol. Obras Sanit. Nación (Arg.) **6:** 346 (Nov. '42). Town of 1200 inhabitants located on left margin of Salado R. in Province of Santiago del Estero. Water supply formerly obtained in part from rain water cisterns and balance from river water supply developed for use of the fed. railroad. Scarcity of rainfall and lack of surface flow in river during dry season of year prompted search for addnl. supply. Since prelim. explorations indicated absence of suitable water-bearing strata to depths of 300 m., decided to utilize subsurface flow of river. Water collected through 120 m. of perforated asbestos-cement pipe 0.200 m. in diam. placed on river bed at depth 3 m. below bottom of river channel and covered with successive layers of gravel and sand. Collecting line discharges into undergound reservoir which also serves as sand trap and as suction sump for booster pumps. Water raised by two diesel-operated pumps to 150-cu.m. elevated tank, 15 m. high. Trunk line and distr. system consist of 3560 m. of asbestos-cement pipe ranging from 0.100 to 0.060 m. in diam. Water to be delivered free of charge at public fountains. Actual tests showed infiltration bed yield close to 10 cu.m. per hr. Flow more than double anticipated vol. Constr. of underground and elevated reservoirs well under way and remainder of project expected to be completed by March '43 at estd. cost of 103,000 Argentinan pesos. —*J. M. Sanchis.*

Water Works for the City of Villa Dolores, Argentina. LUIS A. DUPRAT. Bol. Obras Sanit. Nación. (Arg.) **6:** 264 (Oct. '42). City of 17,700 pop. located on left margin of Sauces R. in one of most fertile valleys of Province of Cordoba. This important commercial center experienced rapid growth in recent years. Growth expected to receive added impetus upon completion of La Viña dam which will place 27,000 hectares of land under irrigation. Yield from 2 wells formerly used for domestic supply inadequate and of poor qual. At present, water supply obtained from infiltration gallery consisting of battery of 16 perforated pipes 4.5 m. long and 0.064 m. id. placed under sand bank at intake basin in Sauces R. Gallery yields 6900 cu.m. water per day. Present water consumption avgs. 1800 cu.m. per day. After passing through sedimentation basin, water brought to city by means of a 6500-m. long 0.400-m. id. trunk line. About 90% of line made up of bell and spigot plain concrete pipe. Remainder collar-jointed reinforced concrete pipe. Summer temps. around 40°C. prevented solidification of asphaltic mastic in joints of bell and spigot pipe, thus making difficult performance of hydrostatic test. Only satisfactory method

found involved immediate backfilling of trench over completed joints, uncovering just before making hydrostatic test and replacing soil immediately afterwards. Trunk line capable of carrying 7600 cu.m. per day. Water disinfected with hypochlorite soln. prior to entering distr. reservoir. Reservoir a partly buried, covered circular tank 22 m. in diam. having capac. of 1500 cu.m. 30 cm. soil cover over roof of tank and earthen embankment against portion of wall aboveground provide necessary insulation from high summer temps. New distr. system consists of 18,000 m. cast-iron pipe ranging from 0.300 to 0.060 m. id., 760 m. of 0.400 m. id. reinforced concrete pipe, and 6000 m. of steel pipe ranging in diam. from 0.254 to 0.076 m. This steel pipe reclaimed in very good condition from old distr. system. Because of topographic features, system operates under heads varying from 17 to 30 m. 694 service connections, some of which serve 2 or more dwellings, 42 fire hydrants and 50 blow-off valves in new distr. system.—*J. M. Sanchis.*

Water Works for the City of Villaguay, Argentina. ORESTES J. P. CANTALUPPI. Bol. Obras Sanit. Nación (Arg.) **6:** 286 (Oct. '42). City of 5000 pop. on margin of Villaguay R. in province of Entre Rios. At present, greatest portion of water supply obtained from shallow wells. These wells contamd. for most part by cesspool seepage. Prelim. explorations indicated presence of abundant potable water in strata located at depths of from 45 to 60 m. Combined yield of 2 wells 58 m. deep estd. at 200 cu.m. per hr. Water will be pumped with diesel-operated equip. Reinforced concrete elevated tank of 500 cu.m. capac. being erected. Distr. system will consist of 12,500 m. of asbestos-cement pipe varying from 0.175 to 0.050 m. id. System will have 550 service connections and 8 public fountains. Project expected to be completed during first quarter of '43. Flat rate of 3% of property's effective or potential revenue charged for unmetered services. Metered service rate for hotels, garages, indus. plants, etc., 0.20 pesos per cu.m.—*J. M. Sanchis.*

Recent Progress in Development of Water Supplies in Colombia. LUIS PACHON ROJAS. Southwest W.W. Jour. **24:** 10: 13 ('43). Planning, financing and control of all projects dealing with water supply and sewerage for all communities in Colombia centralized in Ministry of Public Health. Dept. of San. Eng. responsible for design, purchase of materials with govt. funds, constr. and maint. of project for water supply or sewerage. Govt. provides from special funds 60–70% of total costs, state 25–30% and municipality 5–10%. Greater progress made within past 5 yr. than in previous 50 yr. Present limitations, lack of trained personnel, both of engrs. and operators and scarcity of materials and equip. of which practically 100% comes from U.S. and now not available. Training programs for operators in progress, but ample educational facilities for collegiate training of engrs. not available. Being partially solved by sending young eng. graduates to study in leading Am. universities and accomplished through financial help of Colombian Govt., Rockefeller Foundation, Pan-American San. Bureau, U.S.P.H.S. and others.—*O. M. Smith.*

From the 1940 Report of the Water Supply of Amsterdam. Water (Neth.) **24:** 13: 101 ('40); Gesundh. Ing. (Ger.) **64:** 322 ('41). Water supply of Amsterdam consists of fresh water from below dunes, supply collected at Lachen by seepage of rain water and by pumping from polders, and supply from heath. Quant. obtained from sources cannot be increased, and as expected that demand will be doubled by end of century, addnl. sources must be found. Supplies of ground water not available so surface water necessary. Content of chloride in water of Ysselmeer too high for water to be suitable for supply. Supply below sand dunes may be increased by allowing river water, drawn from Rhineland and treated by rapid filtration, to percolate through sand dunes; chlorination may be necessary.—*W.P.R.*

From the Report of the Commission of Water Supply of West Holland. Water (Neth.) **24:** 161, 169 ('40); Gesundh. Ing. (Ger.) **64:** 322 ('41). In West Holland, in '38, about 4.1 million inhabitants served by water supply systems and about 40% of water obtained from surface sources. Annual water demand about 146 million cu.m.; estd. that by year 2000 demand will rise to 385 million cu.m. In contrast to report on supplies of Amsterdam (*see* preceding abstract) considered that satisfactory supply could be obtained by treating water from Ysselmeer. Present water supplies of Holland largely dependent on rivers flowing from Germany.—*W.P.R.*

Sorocold's Water Works at Leeds, 1694. F. WILLIAMSON AND W. B. CRUMP. Engineer (Br.) **172**: 352, 372 (Nov. 21, Nov. 28, '41). Sorocold outstanding figure in hydr. eng. and pioneer in provision of public water supply. System involved forcing water by means of pumps through closed pipes to height where it could be stored in cistern and distributed in underground pipes through streets and into houses. Only pipe materials available, lead and bored trunks of elm trees. Facts demonstrate success of system. Sorocold entrusted with installation of water supply for Derby, "with free liberty to erect water house, water wheel and other engines, laying pipes for conveying water into streets." Agreement signed Mar. 5, 1691/2. Corporation of Leeds approved similar design on Mar. 3, 1693/4. In 1790 comrs. thought it advisable to replace Sorocold's water wheel by steam engine. With dawn of 19th Century contamn. of river water obvious and is commented on in early description of new works. Point of immediate interest in description, provision of increased storage. Plan of Leeds in 1815 shows choice of datum by following system: "Figures in streets denote el. of those places in ft. and in. above waste weir of water works engine on east side of bridge."—*H. E. Babbitt.*

Dublin Water Supply. The Liffey Aqueduct. R. M. YOUNG. Surveyor (Br.) **101**: 83 (March 6, '42). Dam across river Liffey, constructed in '39, forms reservoir to be used to supplement supply from Vartry and Dodder Rivers. Main quant. of water will be available for elec. Works constructed solely for corporation consist of aqueduct and pipe lines, filtration plant and service reservoirs. Water drawn from reservoir through tunnels to filtration works with capac. of 5 mgd. (Imp.). Concrete aqueduct ends at Dublin with total length of 12.3 mi. Filtration works situated 1 mi. from intake. Water dosed first with 1.5 to 2 gpg. (Imp.) alum, then enters sedimentation tanks holding 9-hr. flow, after which it passes through rapid gravity filters. Odors and tastes removed by activated charcoal, and sterilization is by chloramine process. Finally pH of water increased by addn. of hydrated lime.—*H. E. Babbitt.*

Sydney Water Supply. ANON. Civ. Eng. (Br.) **37**: 214 (Oct. '42). Recent succession of droughts has drawn attention to serious problem of water supply of Sydney. Conditions governing evapn. in Australia so severe that, of 51 stations in Commonwealth, only 1 shows rainfall exceeding evapn. In 1869, water supply drawn from Botany swamp inadequate for growing city's requirements. Four weirs constructed on various tributaries of Nepean R. First dam constructed was Cataract, completed in '07, at cost of £428,000. Cordeaux Dam completed in '26 at cost of £953,000. Last of four weirs replaced by Nepean Dam, in '35, at cost of £1,455,000. Catchment areas totaled 265 sq.mi. Dam on Woronora R. approaching completion. Estd. to cost £1,993,-023. On completion, daily supply for Sydney will be 137 mil.gal. (Imp.). 58′ weir constructed at junction of Warragamba and Nepean R. provides 30 mgd. (Imp.). Next step will be construction of dam on this site, to cost £3,250,000. Expenditure on Warragamba scheme £1,210,287.—*H. E. Babbitt.*

Brisbane Water Supply. *Annual Report 1940–41.* Wtr. & Wtr. Eng. (Br.) **44**: 111 (May '42). Area of city is 375 sq.mi. with pop. of 909 per sq.mi. Total quant. of 6,057 mil.gal. (Imp.) delivered to consumers, decrease of 0.38% from previous year. 338,087 consumers within dept.'s dist. and 23,543 within city of Ipswich. 10 mi. 50 chains 4$\frac{5}{6}$ yd. new mains laid; 2,158 new services laid and 558 new meters installed, bringing total to 53,046. Tests of mains and services 103,353; visible leaks detected 4,635 and invisible 2,394. Lake Manchester pumping station not used during year. No floods in Brisbane R. in which there was fair flow throughout, except for dry period in Oct.-Nov. '40. Mt. Crosby pumping station pumped 6,450 mil.gal. (Imp.) pumping 1,000 gal. (Imp.) per 5,353 lb. of fuel. Holt's Hill slow sand filter plant filtered 1,683.62 mil.gal. (Imp.), or 38% of plant capac. Avg. filter run 28 days. Total quant. of water filtered by rapid sand filter plant 4,105.76 mil.gal. (Imp.), or 94% of plant capac. Approx. 10 mil.gal. (Imp.) drawn from Gold Creek reservoir. 12″ main of Redcliffe Water supply completed toward end of '40. 72,000 cu.yd. concrete placed in Somerset Dam of Stanley River Scheme, bringing total to 184,000. Total expenditure on scheme to June 30, '41 £1,367,026. Bacteriologically, waters of high std. at all times.—*H. E. Babbitt.*

Water Supply in New Zealand. *Auckland Water Engr's. Rept. 1940–41.* Wtr. & Wtr. Eng. (Br.) **43**: 293 (Oct. '41). Total amt. of water supplied during yr. by gravitation 4.117

billion gal. (Imp.), increase of 6.74% over previous yr. Storage in 3 reservoirs, when full, 1.569 billion gal. (Imp.). Pop. supplied, 162,000. Annual rainfall, 36.75", with 4.88" in May and 0.84" in Dec. Filters operated satisfactorily. Avg. dose of alum, 0.64 and, of quicklime, 0.33 gpg. (Imp.). Wash water, 1.06% of filtered water. Total length of new mains laid, 18.5 mi. Total length of city-owned mains now 484 mi. 45 chains. First section of new reservoir at Hopetoun St., contg. 1.5 mil.gal. (Imp.) completed and filled. Terms for supply of water to North Shore boroughs under discussion during yr. Health dept. decided to obtain legislative authority to require boroughs to obtain supply from city. Rapid growth of demand in recent years points to necessity of further augmentation works in relatively near future. Provision made in ests. for recommencing investigations of further sources of supply. *1941–42. Ibid.* **45:** 112 (Sept. '42). Total quant. of water pumped 4.356 billion gal. (Imp.) for pop. of 162,000. Rainfall at Auckland totaled 42.58". Under Development Loan of £225,000 works undertaken included: site for 6 mil.gal. (Imp.) service reservoir on Mt. Albert; laying of various mains; and, to conserve forest lands, acquisition of area of 4,117 acres in Hunua Ranges. Total length of new mains laid was 17 mi. 31 chains, in addition to which a total of 902 new services were provided.—*H. E. Babbitt.*

Gibraltar's Water Supply. ANON. Wtr. & Wtr. Eng. (Br.) **44:** 4 (Jan. '42). Rock's huge underground storage tanks can store over 20 mil.gal. (Imp.) of fresh water. Much of this used up by end of summer. Important new source lately became available by chem. treatment of well water not previously used for drinking. For first time in Gibraltar's history, at end of summer season more water flowing into reservoirs than being drawn off. In one of cavern tanks, whitewashed walls rise nearly 40' and above tank is 60' of solid rock. Over 60 acres of artificial and natural catchments and more than 19.0 mil.gal. (Imp.) flow into tanks from artificial catchments. Up to '36, garrison depended on rain water. In '36 well constructed bringing fresh water from Spanish mountains and another well was discovered later. With its underground reservoirs and bombproof pumping station, Gibraltar's water system outstanding feat of eng.—*H. E. Babbitt.*

The Rand Water Board. *Chief Engineer's Annual Report.* J. P. LESLIE. Wtr. & Wtr. Eng. (Br.) **44:** 30 (Feb. '42). Report for year ending Mar. 31, '41 indicates increasing demand. Area now supplied is 1,959 sq.mi. Constituent authorities supplied comprise municipalities, South African Ry. Adm., Transvaal Chamber of Mines, Victoria Falls and Transvaal Power Co., etc. with total population of 1,139,854. Sources of supply consist of Vaal River, two series of boreholes in Klip River Valley, and wells at Zuurbekon pumping station. Quant. of water available 70 mgd. (Imp.). Water pumped during year 19.23 billion gal. (Imp.) of which 1.347% unaccounted for, including leaks, water for cleaning reservoirs, evapn. and errors in metering. Annual rainfall was 41.00" as compared with 52-yr. avg. of 32.96 in. Storage provided at pumping stations is 18.5 mil.gal. (Imp.) and on Witwatersrand 50.074 mil.gal. (Imp.) System consists of 449 mi. of pipelines, extending from Vaal River at Vereeniging to Central Rand, distance of 36 mi., and along Witwatersrand distance of 80 mi. Cost of pumping 1,000 gal. (Imp.) raised 100' dropped from 0.1111d to 0.1049d as compared with previous year. Discharge of Vaal River 494,595 mil.gal. (Imp.) as compared with 857,792 for previous yr. Water for general supply maintd. in highly satisfactory condition. 18,011.57 mil.gal. (Imp.) taken from river carried 18,327 tons suspended matter removed in sedimentation tanks and filters. Hardness of river water remained low except for short periods. Immediately before being pumped from Vereeniging pumping station all water received treatment with chlorine. Decided in Mar. '41 to carry out following work: (1) alteration to sedimentation tanks; (2) addnl. suction main at Zwartkopjes; and (3) 48,000' of 54" pipe, total expenditure £400,000.—*H. E. Babbitt.*

Durban (S. Afr.) Water Supply. *Annual Report of City Engr.* Wtr. & Wtr. Eng. (Br.) **44:** 83 (Apr. '42). Increased consumption called for increase in supply. Intake for emergency scheme located 2 mi. from filtration works, with two pumps each capable of max. capac. of 3,750 gpm. (Imp.). Rapid gravity filtration works, most modern in country, capable of supplying 5 mgd. (Imp.). Umgeni Water Scheme provides dam on Umgeni R. with capac. of over 5,000 mil.gal. (Imp.) to cost £1,750,000. Unique feature is

flood diversion works which makes possible diversion of whole river flow, preventing deposit of silt in reservoir. Total water treated at Shongweni Works represented daily avg. of 11.645 mil.gal. (Imp.). Camperdown works handled total of 2,224.124 mil.gal. (Imp.), sending 701.48 mil.gal. (Imp.) to Durban. Addn. of liquid chlorine continues. 75.065 mil.gal. (Imp.) supplied to shipping; total consumption during year was 4,631.892 mil.gal. (Imp.) with daily max. of 15.192 mil.gal. (Imp.).—*H. E. Babbitt.*

East London (S. Afr.) Water Supply. J. A. Chew. Surveyor (Br.) **101:** 101 (Mar. 20, '42); Wtr. & Wtr. Eng. (Br.) **44:** 85 (Apr. '42). Supply at present drawn from lower reaches of Buffalo R. and pumped to two storage reservoirs with joint capac. of approx. 355 mil.gal. (Imp.). Scheme will allow addnl. installment to provide storage for max. supply of 8 mgd. (Imp.). River, particularly at low flow, carries relatively high concn. of salt. When dild. with flood water, relatively pure. Present method of selection requires plant capac. of 120 mgd. (Imp.) to raise sufficient water while qual. considered satisfactory. Proposal investigated was Fort Murray scheme comprising reservoir in bed of river and diversion tunnel making possible elimination of undesirable flows and collection of whole flow of river when water good. Question of waste also received attention. Survey made by hydrant sounding. Water unacctd. for in '39 approx. 15% of total consumption, while in '40, only 8½%.—*H. E. Babbitt.*

Waterval Boven Water Supply [Transvaal]. A. F. B. Haylett. Proc. S. Afr. Soc. Civ. Engrs. (Jan. '41). p. 8. Waterval Boven, railway depot on Eastern Transvaal system of the S. African railways, obtains water from Elands River for domestic use and for use on ry. Water treated with alum and lime and aerated in open channel, settled in ponds, filtered, and chlorinated. Filter consists of iron cylinder divided into 6 cells, each of which contains avg. of 110 unbleached sea sponges, so arranged that all water passes through them; each cell can be used independently. Advantages of this type of filter are its compactness, rapidity of filtration, and ease of cleaning. Rate of filtration 16 times as high as that of any type of rapid sand filter, and results obtained stated to be apparently as good. Cleaning done every 24 hr. and takes about 20 min. Carried out by reversing direction of flow of water through filter and, by means of piston, compressing sponges in each cell in turn until clear water shown in glass inspection gage. As sponges shrink slightly after use, extra sponges must be added to each cell after certain period. Deposits of lime and alum removed from sponges by treatment with weak soln. of hydrochloric acid; sponges in each cell in turn removed, washed in acid and then in clean water, and dried in sun. Initial cost of plant comparatively high but costs of maint. low. Tables given showing results of chem., phys., and bact. anals. of water before, during, and after treatment. Turbidity and solids in suspension completely removed, and *Esch. coli* present in 1 ml. of raw water absent in 10 ml. of effluent.—*W.P.R.*

Annual Report, Baghdad District Water Supply, 1941. Anon. Wtr. & Wtr. Eng. (Br.) **45:** 156 (Oct. '42). During year '41, c-i. and steel pipes unobtainable, but asbestos-cement pipes still being imported. In ground where uneven support may occur, asbestos-cement cannot be regarded as reliable substitute. In immunity from corrosion asbestos-cement pipes excellent. Max. water pumped approached 8.5 mil.gal. (Imp.) in one day. Quant. of water pumped during year totaled 9,115 million cu.m. 5,792 new service pipes laid—2,811 of copper, 2,572 of coated steel and 409 of galvanized steel. Sedimentation basin at Karrada is 160′ long, divided into 5 compartments, total capac. being 3,000 cu.m. Settled water delivered by 2-stage pumps through 6 pressure filters. Chlorine and ammonia app. installed for sterilization. Hussein St. tank originally constructed on tower of reinforced concrete columns 6.5 m. high. Developments made pressure insufficient. Decided to raise tank, although undertaking very difficult with limited resources. Tank with steel columns attached raised by jacks operated from top of concrete substructure. Total lift 8½′. In present conditions, impossible to execute large works, owing to difficulty of obtaining materials. Extension must be completed by '45. Proposals are for duplication of Sarrafiya Works.—*H. E. Babbitt.*

Water Supply and Drainage in the United Provinces, India. Anon. Surveyor. (Br.) **100:** 46 (Aug. 8, '41); Wtr. & Wtr. Eng. (Br.) **43:** 320 (Nov. '41). Now 25 public water supplies in United Provinces as against 12 in '20.

Total urban pop. of 1,566,061 supplied with piped water. Total consumption was 43.01 gpd. (Imp.) per capita at Bernares, highest, and 3.13 at Gola Gokarannath, lowest. Water supply maintd. without serious breakdown during year. Extensions to distr. systems carried out haphazardly with result that pressure totally inadequate. Waste prevention measures in most cases not adopted.—*H. E. Babbitt.*

Water Supply and Drainage in the United Provinces. *Report for the year ending March 31, 1941.* F. D. Tunnicliffe. Surveyor (Br.) **101:** 204 (June 12, '42); Wtr. & Wtr. Eng. (Br.) **45:** 110 (Sept. '42). Total pop. of 2,290,868 supplied with piped water by 25 different water works, 23 being publicly owned and 2 privately owned. Census figures of '41 disclose enormous increase in pop. Larger works have not kept pace; accordingly scarcity continues unabated. Complaints rife. In most towns no standby plant whatsoever. Public resents imposition of meters which really only effective remedy. Position now extremely serious. Would appear to be no other alternative but to reduce hours of supply still further. Drainage conditions also deteriorated and poln. of rivers in vicinity of larger towns scandalous.—*H. E. Babbitt.*

Colonial Medical Reports, No. 373, Federated Malay States, Water. Trop. Med. Hyg. **44:** 38 (Oct. 1, '41). Total no. of samples of water examd. 3,021 as compared with 3,764 in year '37. Examn. of treated and untreated waters carried out at frequent intervals. 596 samples from supplies subjected to cuprichloramine treatment examd. for copper and ammonia. Results of anals. show that all supplies in Federated Malay States that receive chem. treatment and mech. filtration continue to yield excellent filtrates. Although most of these waters treated with chlorine or chloramine as final safeguard, majority of them contain no *Esch. coli* in 100 ml. after filtration. Expts. carried out for health officers and engrs. in connection with correct chem. dosage of new water supplies. Frequently demonstrated that correct pH necessary for optimum pptn. with alum or aluminum sulfate. In case of acid water from large well, reported that addn. of lime in quants. equivalent to 12 gpg. failed to produce neutral or alk. water. Both lime and water were therefore examd. and found that aeration of water with addn. of lime equivalent to 2 gpg. produced water of faintly alk. reaction. In addn. to regular examn. of larger water supplies, numerous samples from rivers and wells examd. for health officers. These chiefly in connection with supplies to small villages and estates.—*P.H.E.A.*

The Engineer in Malaya. C. A. Middleton Smith. The Engr. (Br.) **172:** 427, 446 (Dec. 19, 26, '41). P.W.D. (Govt.) responsible for provision of water supplies except in settlements of Singapore, Penang and Malacca. Total cost of controlled supplies approx. £3 million. In '37, 9,475 mil.gal. (Imp.) delivered to pop. of 747,930. Only one resident in 5 had supply of piped water in '38. Chief problem supply of pure piped water to places in coastal regions. On west coast no water-bearing geol. formation. Surface wells may dry up. Water from lower levels of deep wells usually acid and corrosive. Similarly, with infiltration water from rivers. Water engrs. condemn mech. filters of proprietary mfrs. for fittings deteriorate. Unfederated State of Johore has spent large sum of money on water supplies. C-i. pipes std. for distr. Practice of lining them with concrete found favor. Steel pipes, mfrd. locally so corrosive that usual wrapping of hessian and bitumen has not saved them, and adequate coating yet to be found. Asbestos pipes, under low pressures successful and concrete pipes under considerable pressure.—*H. E. Babbitt.*

The Shanghai Waterworks Co., Ltd. *Annual Report, Year Ending Dec. 31, 1940.* W. P. Rial. ('41.) Avg. demand was 54.3 mgd., increase of 2.18% over '39, and max. demand 64.64 mgd. Ratio of avg. to max. daily demand was 1: 1.19 and of avg. to max. hrly. demand 1: 1.64. Turbidity of raw Whangpoo R. water reduced from avg. of 261 to avg. of 23.3 ppm., with avg. dosage of 0.87 gpg. alum. Coef. of fineness of river water turbidity was 0.8. Of total output, 25% was filtered through slow sand beds and remainder through rapid sand filters, avg. rate of filtration, in gal. per sq.ft. per hr., being 1.93 and 100, respectively. Avg. no. of days between cleanings of slow sand filters was 14.5 and wash water used in rapid sand plant averaged 2.52%. Larvae of aquatic fly *Diptera Chironomus* again appeared in effluent from 1 battery of rapid sand filters, but addn. of fine sand and decrease in filtering rate kept no. down. Chlorine applied to influent and effluent of rapid sand filters and at main engines, dosage

at 3 points being 0.88, 0.33 and 0.23 ppm., respectively. Neither sulfur dioxide nor activated carbon were used during yr. Only 3 taste complaints received during yr., and slow sand effluent had less taste than that from rapid filters. Chem. and phys. examns. totaled 31,956 and bact. examns. 5,613. Of 1,830 samples of delivered water examd., 98.0% negative for *Esch. coli* in 100 ml., 1.4% positive in 100 ml., 0.4% positive in 10 ml., and 0.1% in 1 and 0.1 ml. Cost of pumping water from river to settling tanks was $16.47 per mil.gal.; from settling tanks to filters, $21.35; and from filters to consumers, $96.71; all of these costs being approx. 2.5 times those in '39 due to large increases in cost of fuel oil, electricity and coal. Latter is reflected in cost of steam, which increased from $2.74 per 1,000 lb. in '39 to $8.16 in '40. Fuel cost per million Btu. increased from $1.22 to $4.02. Mains were tested frequently for electrolytic action and difference in potential between tramway rails and mains exceeded prescribed limit of 2 v. in 94 of 374 tests made. Following receipt of equip. by railway company, this condition markedly improved. Cost of maintg. the 2,129 hydrants in service avgd. $23.13, compared with $14.55 in '39. No. of leaks repaired per mi. of main increased from 7.27 in '39 to 8.09 in '40, increase being considered due to continuance of heavy traffic over uneven roads. Waste inspection revealed 2,336 leaks. Total no. of meters in service at end of yr., 24,416. Estd. that some 13 mgd. being obtained from private borings in company's area of supply.—*R. E. Thompson.*

BOILERS, FUEL AND FEED WATER

Boilers—Past and Present. S. J. Thompson. J. Inst. Mech. Engrs. (Br.) **148:** 132 (Feb. '43). In 1815, Geo. Stephenson built first locomotive. This was set to work at Newcastle upon Tyne and ran for about 40 yr. Boiler cylindrical, 9′10″ long and 4′ diam., with working pressure of 9½ psi. Change after about 20 yr., in which straight internal flue cut off and small tubes substituted, provided design persisting to present. Lancashire boiler with 2 internal flues invented about 1844. These boilers today from 7′ to 10′ in diam., 30′ long, built to operate at pressures up to 250 psi.; may be fitted with mech. stokers, superheaters and economizers and will then evap. 12,000–15,000 lb. per hr. at 75–78% eff. Scotch marine boiler, originally developed to conserve space, today mfd. with 2, 3 or more furnaces, either single or double-ended, with max. diam. about 17½′ and max. working pressure of 220 psi. Prin. of water-tube boiler that of sepg. water into small sections so that each can be exposed to max. amt. of heat. Type dates back to before A.D. 78. Stephen Wilcox boiler in 1856 used inclined water tubes extending over fire between water legs placed at front and back; in 1867, this boiler assumed now more familiar form of Babcock and Wilcox, which appears to have been first sectional water-tube boiler with free circulation in one continuous circuit. Development of steam turbine caused increasing requirement for larger boilers, with higher pressures and temps.; only type of boiler which could expand to deal with these increasing demands was water-tube boiler. Required pressures in 1900 about 120 psi.; between 1900 and 1907 pressures increased to 160 psi. and generating steam superheated to final temp. of 600°F. From '07, water-tube boilers increased, then common to use boilers evapg. 20,000 lb. per hr. at 200 psi. and final steam temp. of 600–650°F., while generator rating about 1000 kw., with surface condensers. Since '20, pressures, rates of evapn. and steam temps. steadily climbing; at present time, steam pressures of 650 psi. gen., with many plants operating at 850 psi.; normal steam temps. now 850°F., with 900°F., and even 960°F. obtained; boilers with 200,000 lb. per hr. evapn. now common, with few boilers of order of 550,000 lb. per hr. Changes resulted also in increased overall station eff. Water walls universally adopted in modern boilers. Each new development resulted in new problems; author mentions main ones: (1) metallurgical problems in finding suitable materials for increasing temps. and pressures; (2) resultant feed water problems; (3) increased combustion chamber and stoker ratings involving control of air supply, secondary combustion, carryover of grit, deposits on external surfaces of boilers, superheaters, economizers and air heaters; (4) increased boiler ratings in order to keep overall size of plant within reasonable limits; (5) increased controls and instruments required. In large water-tube boiler, various auxiliaries apt to assume appreciable proportions; proportional cost of various ones in avg. boiler unit are: boiler and superheater, etc., 44%;

economizer, 9%; air heater equip., 9%; draft plant, 14%; mech. stokers, 12%; chimney, ash plant, vacuum plant, soot blower, etc., 10%; instruments and controls, 2% (variable, may go up to 7%). When steam temps. did not exceed 700°F., variation of 50°F. ± not of grave import, at 900°F., however, increase of 20°F. for several hr. might easily reduce working life of boiler several yr.—shows importance of controls at these temps. and automatic equip. required, with further complication of plant. Welding playing an increasingly important part in boiler constr. At present time, greater attention being paid to "boiler availability" even at expense of some thermal eff. of plant. As example, plant designed for 87–89% eff. (based on gross calorific value of fuel) must necessarily have low exit gas temps.; this may result in corrosion and deposits in air heaters which may result in plant being shut down and thereby reduce availability of whole plant. Reduced availability may be due to: (1) deposits on external heating surfaces; (2) use of unsatisfactory water; (3) leaky joints; (4) unsuitable fuels; (5) inadequate maintenance staff. Article illustrated by plans and photographs of boilers and installations. In closing, author compliments open way of discussion in U.S. with regard to plant operating difficulties, etc. — *Martin E. Flentje.*

Operation of High Pressure Boilers. Fred D. Mosher. Heatg. & Ventg. **40:** 37 (Apr. '43). Operation of h-p. boilers must be definitely planned. Must extract from units mech. performance expected. Fuel utilization must be efficient under all conditions. Outages should be scheduled, not forced on plant. Rapid advances of boiler pressures to higher levels aggravated problems in feedwater conditioning. Primary requirement to start with clean surfaces. Misunderstanding too common that *compds.* will remove scale. Idea wrong. Term connotes thought boiler water troubles correctable with patent-medicine-like concoction. Heavy deposits in boiler tubes removed only by mech. cleaning which requires much effort, loss of boiler service and expense. More recent method uses properly inhibited acids to dissolve and remove deposits. Once surfaces clean, however, accepted methods of scale prevention used successfully. Maintg. clean steam-side surfaces means preventing silica, Ca and Mg salt deposition, particularly liable at high pressures. Control methods are: regular blowdown, removing undesirable material before feeding water goes to boiler and subsequently treating boiler water to prevent deposits from final traces. External treatment accomplished with lime and soda process best suited to nature of plant. Boiler water further conditioned by subsequent treatment with soda ash, phosphates and tannins or other agents to maint. alky., reduce hardness and perform dispersive functions. Recommendations for water conditioning belong to feed water chemist, but controls and regular checks part of boiler operation. Corrosion source of much difficulty. Best known preventives are complete de-aeration of dissolved gases, e.g., O_2 and CO_2, and maintg. alk. feed water by providing excess Na_2CO_3 to proper deg. according to pH test. Winkler D.O. test sufficiently accurate. Min. routine checks should include those for: dissolved solids, pH, hardness and D.O. To prevent caustic embrittlement recommend boiler water treatment with sulfates to inhibit caustic soda action. A.S.M.E. ratio for h-p. boilers requires 3 parts Na_2SO_4 to 1 of caustic soda (NaOH). Article also includes discussions of: scheduling outages, instruments and their use, powd. coal, stokers, oil-fired equip., combustion and boiler losses due to excess air, too little air, leaks in boiler setting, radiation, dirty heat transfer surfaces and failure to use instruments properly.—*Ralph E. Noble.*

The Use for High-Pressure Boilers of Water Treated, When Hot, for Removal of Silica and With Wofatit for Softening. W. Wesly. Chem. Tech. (Ger.) **15:** 41 ('42). Describes results of 20-mo. operation of h-p. boiler installation using process of softening and silica removal. Material known as "Hydrat," prepd. from calcined dolomite and of which compn. given, found to be more effective than magnesium oxide for removing silica from water, and equal to lime in capac. for softening. Reduced content of silica to 0. mg./l. and carbonate hardness to 0.7° (Ger.). Settling of ppt. also satisfactory when "Hydrat" used; therefore adopted for use in plant. Part of sludge recirculated to improve removal of silica. Water filtered through Magno filters. Hot boiler water used for washing filters. To prevent attack of resins, water neutralized with sulfur dioxide before softening; sulfites formed removed D.O. from water. At this stage, water has avg. hardness of 3. (Ger.). In first Wofatit filter, hardness reduced to 0.02° and in second filter to 0.01

(Ger.). Hot soln. of common salt (concn. 65 g./l.) used for regenerating filters; filters then washed with hot boiler water from which sludge removed. Ammonium phosphate added to boiler instead of adding both sodium phosphate, to ppt. any residual hardness, and ammonium sulfate, to neutralize caustic alky.; content of salt in water thereby not increased to same extent. Compn. of water at different stages of treatment shown in tables and graphs. Alky., concn. and content of phosphates in boiler water detd. every 4 hr. and content of silica twice a day. Previously shown that steam free from silica obtained when content of silica in boiler water not more than 4.5 mg./l. Feed water contained avg. of 0.25 mg./l. silica; concn. in boiler should not be allowed to exceed 4.5, i.e., 18 times concn. in feed water. Salt not deposited in turbines when alky. no. of boiler water did not rise above 40. During first months of operation of plant, not possible to maint. concn. and alky. at desired levels. Steam had content of solids of about 1 mg./kg. consisting mainly of sodium sulfate; silica could not be detected. Some ammonium carbonate present in condensate. Steam contained 400–500 ml. noncondensable gases per ton, including up to 300 ml. hydrogen; this quant. harmless. Until Oct. '40 water-soluble salts deposited in turbines, but silica not deposited. To prevent carry-over of salts, steam space in boiler increased by lowering water level.—*W.P.R.*

Safety Valves for Water-Heating Boilers. EDWARD INGHAM. Internatl. Engr. **82:** 189 (Dec. '42). (Reprint in part from Indus. Heatg. Engr. (Br.) Apr. '42). Long ago, widespread impression that safety valve unnecessary when normal pressure in water-heating boiler low, and communication existing with open tank or free vent to atmosphere. Impression overlooks possibility of closing communication with ice, scale in pipe or closing of stop taps or valves. Valve bore should be not less than $\frac{3}{8}$'' in diam. Size refers to diam. of valve opening. Factors causing valve leakage include: hammering on seat by water-hammer shock, vibration, scale deposits about seat. Rubber facings undesirable because rubber deteriorates, squeezes out and may cement to seating and make it inoperative. Metal to metal contact best. Valve should be suitably encased to protect from dust, dirt; permit testing without risk of scalding; have locking arrangement to prevent tampering. Dead-weight safety valves generally more reliable than spring-loaded. Spring may lose elasticity or break. Should be tested daily.—*Ralph E. Noble.*

Water Lancing. ANON. The Engr. (Br.) **174:** 366 (Oct. 30, '42). Problem of effect of high-temp. external deposits accentuated by wartime fuel supplies. Felt that information on water lancing as means of dealing with deposits of interest to engrs. Process involves subjecting slag to repeated quenchings with cold water while boiler is working. Equip. necessary of simple nature and can for most part be improvised.—*H. E. Babbitt.*

Intercrystalline Cracking of Boiler Steel and Its Prevention. W. C. SCHROEDER & A. A. BERK. U.S. Bureau of Mines Bul. 443 ('41). Lack of understanding of problem of intercrystalline cracking or boiler embrittlement resulted in extensive investigation in '32 by Joint Com. on Boiler Feed Water Studies in co-op. with Bureau of Mines. Embrittlement cracking distinguished from that caused by fatigue, corrosion fatigue, stress or temp. stress cracking, by its predominantly intercryst. nature. Investigation developed that intercryst. cracking caused by: (1) slight leaks such as may occur in riveted seams or tube ends which allow loss of steam and concn. of boiler water; (2) boiler metal must be under internal or external stress; and (3) concd. boiler water contg. NaOH and Na_2SiO_3 must be in contact with stressed steel. Testing equip. developed to simulate those conditions and can be used on operating units or with exptl. bombs in lab. Tests made and records collected do not confirm claims made for use of Na_2SO_4 as protective agent. Sodium nitrate found effective in preventing intercryst. cracking up to 300 psi. Quebracho prevented cracking in lab. tests up to 600 psi. Waste sulfite liquor beneficial in many cases, but failed in some. Use of embrittlement detector recommended for checking individual operating conditions and detg. type and amt. of most suitable inhibitor. Methods for detg. sodium nitrate, waste sulfite liquor and quebracho given.—*R. C. Bardwell.*

Cause of and Remedy for Pitting and Corrosion of Locomotive Boiler Tubes and Sheets, With Special Reference to Status of Embrittlement Investigations. R. E. COUGHLAN *et al.* Am. Ry. Eng. Assn. Bul. 434, p. 144 (Nov. '42). Results from tests with specimens applied to boilers in actual operation in-

dicate that treatment of water with $NaNO_3$ as recommended by Bureau of Mines beneficial for preventing intercryst. cracking. Embrittlement detector tests with one type of carbon molybdenum steel showed no improvement in cracking resistance.—*R. C. Bardwell.*

The Priming of Boiler Waters. E. G. BARBER. Eng. Boiler House Rev. **55:** 156 ('41). Discusses causes and nature of priming in boilers. Priming usually accompanied by variations in level of water in boiler and by sudden drops in temp. of superheated steam. Concn. of sodium compds. in boiler water important factor with respect to priming; nature of compds., whether chloride, sulfate, hydroxide or carbonate, of minor importance. Presence of soap in boiler water causes priming under nearly all conditions. Priming dependent on type of boiler used. Foaming prevented by castor oil, but effects not permanent. Treatment of feed water with 5–10 ppm. of emulsion of tannins and castor oil beneficial, especially for locomotive boilers. To prevent priming in boilers, feed water should contain more than 500 gpg. dissolved solids at gage pressure below 150 psi., between 150 and 500 gpg. at gage pressures between 150 and 300 psi., and between 50 and 150 gpg. at gage pressures between 300 and 600 psi.—*W.P.R.*

Scale Removal From Pipe by Simple Treatment. HARRY F. SIMONS. Oil & Gas J. **40:** 49: 29 ('42). Sodium hexametaphosphate and alk. quebracho tannin widely used in treatment of drilling mud, for treating boiler feed water and water used in radiators and cooling systems. Application for removal of scale from interior of pipe and tubing indicated. Article describes application of these chems. to line carrying salt water for disposal. Scale thickness of $1\frac{1}{4}''$ reduced to $\frac{1}{8}''$ in 4 mo. by using 0.2 lb. of mixt. of above chems. to each 100 bbl. of salt water carried through pipeline.—*C.A.*

The Suitability of the "Polyradia" Process for the Prevention of Scale in Steam Boilers and Evaporators in Sugar Factories. O. SPENGLER, S. BÖTTGER & W. DÖRFELDT. Z. Wirtschaft. Zuckerind. (Ger.) **91:** 103 ('41). Action of "Polyradia" process ascribed to radioactivity. App., called "Nutzstrahler" (commercial radiator), consists of sealed glass tubes filled with radioactive salts, being sold by French firm Traitements Radioactifs Industriels. In use, radiator hung in liquid to be softened, where it operates automatically without further supervision. Authors have conducted controlled tests on action of radiator both in lab. and semi-plant trials with boiler water as well as sugar juices. Parallel expts. always carried out: (1) without exposure to rays; (b) with exposure to "Polyradia-Nutzstrahler"; (c) with exposure to known radioactive substance; and (d) with glass tube without radioactive filling. Throughout, no action, outside of exptl. error, demonstrable. Only in one case, during concn. to about half vol. of boiler feed water in available evapr., noticeable slight tendency in reduction of incrustations. Since authors obtained effect only in boiler water trials with their tubes contg. known radioactive substance, possibility exists that under certain circumstances use of weakly radioactive substance might lead to decrease in scale after long operation. To be noted, however, that with "Polyradia" no specific radioactive action could be shown. [Sale of this device under other names promoted both in Canada and U.S. It will probably appear again under another name. Inclusion of this abstract not to be taken as endorsement of the process.]—*Ed.*

Silica Removal by an Improved Magnesia Process. H. L. TIGER. Trans. A.S.M.E. **64:** 49 (Jan. '42). Modern h-p. boilers with high feed water make-up requirements frequently demand reduction of dissolved silica. New magnesia process for silica removal developed, combining flexibility, simplicity, and economy. Can be applied to any type of water at any temp. Can be carried out in conjunction with usual pptn. softening process. Increase in operating cost very small. Results accomplished by new method of combining no. of principles embodied in process. Extensive investigations conducted to determine influence of each of various factors on final result, and data presented on effects of following: form of magnesium used (whether pptd. ionic Mg or undissolved Mg compd.), temp., sludge-magnesium concn. and agitation for sludge-water contact. Principles of increasing Mg^{++} content, when required, by means of novel sludge recycling process with magnesium dissolver described. Method of using cheap dolomitic lime as low-cost source of magnesium also presented. Process lends itself advantageously to modified Spaulding precipitator type of constr. at either low or high temp., to be followed by suitable treat-

ment with carbonaceous-ion exchangers, when required, for complete removal of residual hardness and reduction of alky. to any predetermined figure. Article detailed and exhaustive with many curves and diagrams. Conclusions of research and studies: (1) For any given set of conditions, ionic Mg pptd. *in situ* as $Mg(OH)_2$ most efficient, but undissolved Mg compds. of proper qual. (fine-particle size, etc.) also give satisfactory results when favorable conditions of sludge concn., agitation, etc., maintd. (2) Eff. of removing silica by pptg. ionic Mg or by undissolved Mg compds. increases with temp., but application of other factors disclosed makes it possible to obtain satisfactory results at low temp. Slight prewarming of water to about 30 to 40°C. (86 to 104°F.) reduces Mg required to obtain desired result; waste heat usually available for this purpose. (3) Eff. increases with concn. of Mg-contg. sludge in contact with water. (4) Increasing time of contact with sludge absorbent in agitated suspension improves results. (5) Reducing silica contamn. of retained concd. sludge reduces silica in effluent; thus if Mg added to system increased, ratio of Mg : SiO_2 in sludge rises correspondingly, and residual SiO_2 in effluent decreases. (6) Presence of phosphate ion interferes with silica absorption by MgO. (7) In those cases where addnl. Mg required for desired silica reduction, can usually be obtained most economically from dolomitic lime ($Ca(OH)_2MgO$); where no lime required in treatment, calcined magnesite (MgO) used. (8) Ionic Mg may be added to raw water economically and without increasing lime requirement or total-solids content of effluent by recirculating sludge into magnesium-dissolver compartment or low pH zone, where HCO_3^- and CO_2 in raw water dissolves Mg^{++} from this sludge. If necessary, additional CO_2 may be added by flue-gas carbonation to increase further amt. of Mg^{++} introduced. (9) In applying this silica-removal process, economic balancing of findings to produce desired result requires careful consideration of all facts in any given case. Data show that silica may be removed efficiently both at low and high temps. In general, following may be stated with respect to the equip.: (1) If hot-process lime-soda treatment applied to reduce hardness, superior silica-removal results obtained by using equip. embodying positive agitation and intimate sludge contact like that provided by Spaulding precipitator type hot-process softeners. (2) If hot-phosphate softening used, silica-removal treatment should be carried out first, and phosphate treatment should follow. (3) If treatment applied at low or medium temps. (cold-process treatment), silica removal applied first, and advantage may be taken of post-treatment by carbonaceous zeolites, which completely eliminate any residual hardness. Carbonaceous hydrogen-zeolite treatment may also be included to reduce final alky. to any predetermined figure. These carbonaceous zeolites, being nonsiliceous, can treat effluent of silica-removal plant without danger of silica pickup from zeolite by water.—*Ed.*

Removal of Silica From Water With Alkaline Earth Compounds. W. Ufer. Angew. Chem. (Ger.) **54:** 496 ('41). Discusses removal of silica from water by means of alk. earth compds. Process involves 3 stages: addn. of soluble reagent, removal of silicates and other insoluble compds. and pptn. and removal of excess dissolved reagent. Barium and strontium hydroxides more soluble than calcium hydroxide, but, in practice, lime only reagent sufficiently cheap to be used. Removal of silica then combined with lime-soda process of water softening. Carbon dioxide from flue gases can be used for removing excess lime. Tests made at 30° and 100°C. in which varying amts. of lime added to water contg. 7–8 mg/l. of silica. When small quants. of lime added at 100°C., removal of silica depended on period of contact, but this not so when soln. saturated and solid hydroxide present. Addn. of 4,800 mg./l. of lime at 30°C. reduced content of silica to 0.2 mg./l. Temp. had no effect when excess lime present, but with smaller quants. of lime, removal of silica increased with increasing temp. Lime contg. high percentage of fine particles more efficient than coarser lime. Removal of silica could be increased by passing water satd. with lime through filter of active carbon which had been soaked in milk of lime or lime water. As effluent from filter usually not clear, coagulants, such as salts of iron or aluminum, added. Mechanism of process of removal of silica discussed. When 1.3 g./l. of calcium oxide used, content of silicic acid reduced to 0.7 mg./l. regardless of initial concn. of silica; this value is soly. of silica in lime water. Addn. of solid calcium hydroxide further reduces content of silica by adsorption. In semi-plant scale installation, good results obtained only when as much as 5,000 mg./l. of lime added. This chiefly due to poor sedimentation, so

that silicate redissolved during subsequent treatment with CO_2. Method used for removing excess lime from the water had no effect on amt. of silica removed. Other calcium, barium, strontium, magnesium salts not satisfactory for silica removed.—*W.P.R.*

Formation and Removal of Boiler Scale Containing Silicic Acid. M. Reinhard, E. Brandenberger and G. Oesterheld. Helv. Chim. Acta (Switz.) **25:** 336 ('42). Central station operating at 32 atm. with treated water of 0.2–0.5 German grains of hardness installed by Ciba in '27. Since it is a chem. plant little return condensate. Operations generally satisfactory for 12 yr. Mild scale formed was $CaCO_3$, $CaSO_4$ or mixt. This removed by boring at suitable intervals. Then, suddenly, this succeeded by calcium silicate, xonolite, having structure of asbestos. This could also be bored out. Hard silicate deposits of wollastonite followed. Qual. of personnel deteriorated when war started and in Dec. '39 two explosions. Tubes showed thick semicircular deposits on heated side. Boring equip. could not remove this without eroding metal. Trisodium phosphate added to water going to boilers. Boiler water went as high as 20–40 mg. SiO_2/l. before treatment; when treated rose to 320 mg./l. within 2 days, then gradually declined. After few weeks, on opening boiler, only easily removable nonsilicate scale found. Amt. of excess phosphate appears to have no signif. $CaSiO_3$ converted to pseudomorphous $Ca_3(PO_4)_2$, which remains in suspension or gives spongy deposit, and Na_2SiO_3 in soln. Photomicrographs of various deposits and x-ray studies confirm work.—*C.A.*

Treating Water to Inhibit Scale Formation in Steam Boilers. Howard C. Roller (*to Neckar Co.*) U. S. Pat. 2,262,301 (Nov. 11, '41). Hardness of water reduced by adding $Ca(OH)_2$ and Na_2CO_3 to make-up water and by adding compd., such as $NaHCO_3$, contg. half-bound CO_2 radical capable of retaining such radical at temps. of 100° or higher, to maint. substantial amt. of carbonate radical in water content of boiler.—*C.A.*

X-Ray Fingerprints Scale Deposits. C. E. Imhoff and L. A. Burkhart. Power **86:** 10 ('42). Although chem. anal. dets. elements present in boiler scale, manner of combination must be assumed. X-ray diffraction method identifies not only elements but also combinations in which present. Other advantages of x-ray diffraction method include comparative estn. of particle size, small sample required, sample itself unaffected, permanent pattern recorded and samples from various sections of material can be studied. *Ibid.* **86:** 64 ('42). Review of application of x-ray powd. diffraction technique to study of boilers and turbine scale. Compds. rather than elements identified and particle size and orientation of crystals detd.—*T. E. Larson.*

Field Data for the Embrittlement Detector. E. P. Partridge, C. E. Kaufman and R. E. Hall. Trans. A.S.M.E. **64:** 417 ('42). Neither sulfate nor Cl, nor sulfate and Cl in combination showed evidence of inhibiting effect in boiler waters over the range of pressure above 250 psi. with Schroeder detector. Alumina not effective as inhibitor of cracking nor was phosphate even with phosphate NaOH ratio as high as 2. This does not den[y] possible utility of elimg. NaOH substantially from boiler water contg. phosphate by controlling pH in range below 11. Tannin, as detd. by tyrosine test, seemed effective as inhibitor in tests made up to 650 psi. Extensive data from 100 detectors on operating boilers presented.—*C.A.*

Embrittlement of Boiler Steel. Experiences With the Schroeder Detector. T. E. Purcell and S. F. Whirl. Trans. A.S.M.E. **64:** 397 ('42). With Schroeder detector maint. of A.S.M.E. ratio of Na_2SO_4 to total alky. as Na_2CO_3 did not prevent embrittlement of specimens. NaCl to total alky. ratio of 1.6 in conjunction with A.S.M.E. ratio did not prevent failure of specimens at 420 psi. Specimen cracking not ound in boiler water where alky. controlled on basis of pH value corresponding to phosphate concn. $NaNO_3$ offers possibilities as inhibitor.—*C.A.*

Results of Laboratory Embrittlement Testing of Boiler Waters. F. G. Straub. Trans. A.S.M.E. **64:** 393 ('42). 900 boiler waters tested with exptl. embrittlement tester described. At 400°F. and low NaCl content addn. of sulfates not effective in preventing failure of test specimen, but with NaCl greater than 0.6 of alky. or equal to NaOH content combination of SO_4 and Cl effective. At 425°F., high Cl correlation not as good, although in many cases high NaCl stopped failure. At 470° and 570°F. influence exerted by R_2O_3 in respect to that of SiO_2. When

NaCl low, failure occurred even when R_2O_3 high. Correlations with stationary boiler tests confirmed value of sulfates at pressures where embrittlement prevalent.—*C.A.*

Experience With Intercrystalline Cracking on Railroads. R. C. BARDWELL AND H. M. LAUDEMANN. Trans. A.S.M.E. **64:** 403 ('42). Embrittlement-detector tests and railroad-operating experience have shown that Na_2SO_4 did not prevent or even delay embrittlement cracking in boilers. Waste sulfite liquor prevented cracking in many boiler waters but failed in few cases. Use of $NaNO_3$ essentially elimd. cracking of detector specimens on entire system of C. & O. Ry. $NaNO_3$ easy to apply and has created no difficulty in operation of locomotive boilers, and is most efficient chem. yet developed for intercryst. cracking. Treatment reduced materially repairs to boilers due to cracking.—*C.A.*

Water Treatment to Prevent Intercrystalline Cracks in Locomotive Boilers. W. C. SCHROEDER. Proc. Master Boilermakers Assn. ('41). p. 131. Intercrystalline cracks in boilers result from contact of embrittling water with stressed steel, such as may occur in capillary spaces between riveted seams where slight leaks develop. Embrittlement detector developed at Bureau of Mines for application to operating boilers to det., in 30- to 90-day period, embrittling tendency of water used. Many railroads have these in service. Results indicate some interference with intercrystalline corrosion by treatment of water with waste sulfite liquor in amts. to maint. from 35 to 70% boiler water alky. Treatment with $NaNO_3$ in amt. to maint. this salt at 40% boiler water alky. has practically elimd. cracking of detector specimens on operating locomotives.—*R. C. Bardwell.*

The Cracking of Boiler Plate. P. G. BIRD AND E. G. JOHNSON. Trans. A.S.M.E. **64:** 409 ('42). On basis of tests with Schroeder embrittlement detector on synthetic solns. and boiler waters no indication that inorg. salts ordinarily found in boiler waters exerted pronounced protective action. This also true of Na_2SO_4 while operating well within A.S.M.E. code recommendations. Some tests indicated that high sulfate content may interfere with protective action of organics, but effect not pronounced or consistent enough to draw conclusion that sulfates harmful. With given feed water increasingly larger amts. of inhibitors required as no. of concns. increased. Whether this due to corresponding increase in concn. of neutral salts or NaOH or whether it indicated deterioration of inhibitor in boiler water not detd. Of inorg. substances used to inhibit cracking, $NaNO_3$ one of best when combined with org. matter.—*C.A.*

Boiler-Water Recirculation. E. D. FLICKENGER. Power **85:** 841 ('41). System comprising external treatment with CaO, Na_2CO_3 and Na_2SO_4 and internal treatment with Na_2HPO_4, NaH_2PO_4 and coagulant modified to permit circulation of proportion of blowdown. Quants. of CaO, Na_2CO_3 and Na_2SO_4 required per 1000 gal. thus reduced from 1.13 to 0.95, 0.45 to 0.04, and 0.46 to 0.16 lb., resp. Increase in quant. of phosphate from 0.130 to 0.168 lb. per 1000 gal. caused by change from intermittent to continuous blowdown rather than by recirculation. Estd. reduction in cost of chems. 22.1% and cost of H_2O decreased by 5.8%. Saving in fuel as result of reduced blowdown 16.7 Btu. per lb. steam.—*C.A.*

Failures of Boiler Feed Pipes. EDWARD INGHAM. Eng. & Boiler House Rev. **55:** 57 ('41). Causes of failure of boiler feed pipes include: (1) faulty material; (2) faulty constr.; (3) weakening by repeated stressing and by corrosion; (4) expansive and other movements; and (5) water hammer. Weldless mild steel feed pipes generally regarded as most suitable because of high tensile strength, ductility and general reliability. Feed pipes may be weakened by both external and internal corrosion, latter being commonly more troublesome and being ordinarily caused by presence of oxygen and carbon dioxide or free mineral acids in feed water.—*C.A.*

Change in Piping Corrects Trouble With Boiler Water Level. R. S. HAWLEY. Heatg., Piping and Air-Condg. **14:** 236 (May '42). When 2 new low-pressure 60" horizontal tubular boilers put into operation, operators had difficulty keeping water line in sight on gage glass. Check of water column piping connections located trouble. Piping plans called for feeding return water through blowoff valve connection. Contractor then connected lower end of water column into tap provided for feed-water line in usual place, approx. at lower water level, overlooking tap left by mfr. for purpose, well below water line. Trouble disappeared with piping change.—*Ralph E. Noble.*

CORROSION AND CORROSION CONTROL

Preventing Internal Corrosion of Pipelines. A. Wachter & S. S. Smith. Ind. Eng. Chem. **35:** 358 (Mar. '43). Corrosion decreases capac. throughout, increases operating costs, deteriorates refined petroleum products and reduces thickness of pipe wall. 23% capac. loss during first 2½ yr. of use reported. Lowering of temp. on passing gasoline from chem. treaters to underground pipeline causes separation of oxygenated water phase sufficient to cause widespread rusting. Oxygen about 6 times more soluble in gasoline than in water. Water admitted also for pressure tests of welded joints and during maint. and structural changes. Factors influencing corrosion are: temp., through effect on condensation of moisture and on corrosion rate; gasoline veloc., through distr. of water in suspension and on differential oxygenation; retention of water by rust blisters; quant. of water, by affecting quant. of rust; compn. of water; presence of mill scale, being cathodic to steel increases corrosion where broken and minor effects from nature of refined fraction, through phys. and interfacial properties. Mech. scraping, regularly performed, as palliative measure only partially effective in removing flow-impeding rust; evidence points that subsequent corrosive action increased, as oxygen regains easier access to steel. Removal of water by adsorption in commerical bauxite found satisfactory for 2 yr. on short line, but no protection afforded against operating contingencies in long line. Removal of D.O. by sodium sulfite gave no material benefit on 2 lines. Inhibitors attracted adoption because vol. of water small and injections simple, economical and flexible. Lab. corrosion test method consisted of rotating, at 60 rpm. for 14 days, 4-oz. oil sample bottle contg. 20 ml. water sample, 70 ml. gasoline and 30 ml. air space, renewed every 2 days, in contact with steel rod retained in position by socket in stopper. Results detd. visually and by loss in wt. after cleaning electrolytically and erasure. Corrosion rates, shown by various pipeline water samples, fell into 2 groups, around 0.5 and 5 mils per year. Sodium nitrite only inhibitor to meet all requirements for bright or mill-scaled surfaces. pH of water should exceed 6.0 for protection. Sodium chromate almost as effective, but would deplete gum inhibitor and affect color of gasoline. Sodium chromglucosate gave somewhat similar results and objections, and, in addn., stabilized gasoline-water emulsions. Disodium phosphate and sodium silicate restricted rusting but formed occasional hard scale. Sodium hydroxide fairly protective to polished steel but rust blisters formed over mill scale; also gasoline and water emulsified. Sodium sulfite impractical, due to large quant. needed to react with oxygen. Mercaptobenzothiazole, gasoline soluble inhibitor, gave problematical results. In continuous circulation app., 0.1% sodium nitrite in water phase prevented rusting at gasoline : water vol. ratio above 200,000 : 1, simulating pipeline conditions. Higher nitrite concn. took less injection soln., suggesting protective film of ferric oxide at anodic areas, even though polished steel specimens remained bright. No change detectible in nitrite concn. of aqueous phase in app. Ferric hydroxide does not adsorb sodium nitrite but fresh rust reduces nitrite to ammonia, hence full benefits in pipeline delayed several mo. following introduction. In origin on each station-to-station length where sediment and water trap removes prior liquor, 5 gpd. of 5–30% sodium nitrite soln. injected, with sodium hydroxide added if effluent water falls below pH 8.0. Effect of mech. scraping found improved. Flow factor in 55 mi. of 8″ pipeline increased from $C = 137$ to 155 after inhibition. Inspection showed interior practically clean steel surface. In past 2 yr. economical and complete protection provided for over 800 mi. of products pipelines.—*A. A. Hirsch.*

Increased Use of Lead Coating on Iron and Steel Is Resulting From Recent Studies. Anon. Lead **13**: 1: 2 (Jan. '43). Use of lead (Pb) as protective coating on iron and steel not new, but less common than zinc (Zn) coating or galvanizing; acknowledged more resistant to atmospheric corrosion than Zn, but brighter appearance of galvanizing and pinholes in Pb coating retarded use. Improved technique for hot-dip application produces satisfactory results for many purposes. Rust stains on hot-dip Pb-coated surfaces superficial, soon disappearing, as pinholes apparently sealed by corrosion products. One process uses galvanizing equip. Articles to be coated pickled scrupulously clean, placed in perforated basket, dipped in

dil. H_2SO_4, then in weak HCl soln. and finally in dissolved Zn ammonium chloride bath. While still damp, dipped into coating pot contg. Pb between 675° and 700°F., upon surface of which floats flux layer $\frac{1}{8}''$ to $\frac{1}{4}''$ deep. Flux consists of approx. 85% $ZnCl_2$ and 15% ammonium chloride. Baskets agitated in coating bath about 1 min., articles removed and centrifuged to remove excess metal. While hot, may be tumbled to remove superficial discolorations. Articles from small washers to thin curved 6′ to 8′ sections thus coated, but only smaller items tumbled. Small amts. of tin, antimony or certain other metals in Pb bath advantageous. Pb coating wt. between 50 and 150 mg./sq.in. whereas Zn coatings usually 200 mg. Also, Pb excels all other metals as base for paint, requires no weathering or special prepn. before painting. Another Pb coating method is electroplating. Under certain conditions, hot dipping gives distortions or undesirable surface stresses absent in electroplated objects. Although unsuitable on items requiring brightly finished surfaces and not highly resistant to abrasion, high corrosion resistance, ease of handling and plentiful supply of Pb indicate recent improved processes will save large quants. of Zn, cadmium, chrome, nickel and tin hitherto required for protective iron and steel coatings.—*Ralph E. Noble.*

Films Made by the Metallization Method for Protection Against Corrosion. I. Ya. Klinov. Trudy Moskov. Inst. Khim. Mashinostroeniya (U.S.S.R.) *No. 7*: 49 ('39); Khim. Referat. Zhur. (U.S.S.R.) *No. 6*: 146 ('40). General principles for producing protective coatings on metals by spraying described, and theoretical explanations of phenomena taking place during dispersion of metals in molten state given. Adhesion of protective film to metal obtained by spraying on rough surfaces, prepn. of which predominant factor affecting physico-mech. properties of films. Hardness of metallized film depends on thickness, on distance of spray nozzle from surface, on pressure of burning and spraying gases, etc. Conditions for obtaining max. hardness for various metals applied by spraying described. Presence of oxides in metallized layer explained by oxidation of metals during spraying. Oxides decrease density of protective film. Conditions for obtaining films for protecting basis metal from corrosion and methods for applying films discussed in detail. Zinc and zinc-cadmium films can protect iron and carbon-steel electrochemically from sea-water corrosion, if applied to a thickness of 0.03 mm. Compns. of sea water and increase in temp. to 40°C. have little effect on deg. of corrosion of zinc films. Films cathodic with respect to iron (lead, stainless steels) can protect basis metal from corrosion only if special selection of technical conditions for dispersing metals made. Films of stainless steel possess sufficient chem. resistance in HNO_3 solns. of medium concns., if obtained by spraying molten metal with inert gas, and pores subsequently satd. with silicate pastes or lacquer having base of phenol-aldehyde resins. Metallization with lead for protecting iron from action of H_2SO_4, followed by mech. strengthening by rolling, produces coatings resistant to 70% and 20% H_2SO_4 solns. at temps. up to 80°C. A 0.5-mm. thickness of lead sufficient for 70% H_2SO_4. For 20% H_2SO_4, 0.7-mm. thickness of lead film sufficient.—*C.A.*

"Homemade" Rain, Sun and Wind Test Metals. Anon. Pop. Mechanics **79**: 3: 49 (Mar. '43). "Corrosion tester" is small cabinet in which continual man-made rain, sunshine, wind and any desired chem. action operates. Test metals travel through spray chamber, vertical wind tunnel, 2 immersion tanks and radiant-heat chamber in 85 min. Possible to reproduce every known type of corrosion, e.g., galvanic, concn. cell, intermittent wetting, oxidation and chem.—*Ralph E. Noble.*

New Aspects in the Prevention of Damage to Materials by Hot Water, From the Hygienic and Chemical-Technical Viewpoints. F. Konrich & L. W. Haase. Gesundh. Ing. (Ger.) **64**: 115 ('41). Surveys methods introduced during last 10–15 yr. for prevention of corrosion in hot-water systems. To prevent corrosion of iron by hot water, necessary to remove D.O. from water, or prevent its contact with metal. When sulfites, bisulfites or sulfurous acid added to combine with D.O. in water contg. about 10 mg./l. alkali sulfate or bisulfate, hot water will contain about 120 mg./l. alkali sulfate or bisulfate. This below limit permissible in water used for human consumption. To obtain complete removal of oxygen at temps. used in hot-water plants, necessary to add excess sulfite; high concn. of sulfite in finished water undesirable, as may cause eczema. Process should not be used for waters in which content of D.O. varies

more than ±10% from avg., and addn. of sulfite must be regulated so that excess never exceeds 20%. Temp. must be maintd. above 60°C. to insure reaction between oxygen and sulfite. Attempts made to hasten reaction by means of catalysts. Best catalyst found is copper, and presence in ionic form necessary; can only be used with waters which have slight corrosive action on copper or which do not ppt. insoluble copper compds. Phosphates may be added to water in hot-water systems to form protective layer on metal and to prevent contact between D.O. and metal. Quant. of phosphate added usually adjusted to suit avg. water demand, but this means that sometimes too much or too little added. Less harm caused by addn. of too little phosphate than by addn. of excess. Excess phosphate causes pptn. of hardness-forming substances so that ppt. formed in pipes and phosphate removed before it reaches more distant parts of system. Excess phosphate undesirable in water used for prepg. food as it has buffering action on acids of stomach. Phosphates with least buffering action should be employed, e.g., monophosphates, but as these are acid, can only be used with waters contg. carbonates. Increased temp. increases aggressive action of water as pH value lowered. Condition may be corrected by adding solns. of chems. to neutralize acid, or by filtering water through alk. materials. In addn. to filtering cold water through Magno or other filters, good results obtained when hot water also filtered. Calcium salts formed are deposited in filter and other substances, including iron and manganese, also removed. Even with water not seriously aggressive when cold, filtration reduced corrosion by 80%. Water not aggressive when cold should be filtered through alk. material when hot. Hot-water supplies should be treated in such way that they can be used for any purpose in kitchen. Hot-water supplies must be of good san. qual.—*W.P.R.*

Injury to Pipes by Improperly or Insufficiently Treated Water. F. Börsig. Maschinenschaden (Ger.) **17:** 30 ('40); Chem. Zentr. (Ger.) **111:** II: 111 ('40). Heavy deposits occurring in feed-water line consisted of iron oxides with 4% copper and H_2SO_4. Pipe showed pitted corrosion under deposits. Phenomenon due to soln. of copper from copper pipe by water acidified with H_2SO_4 and H_3PO_4, and subsequent deposition of copper in adjoining iron pipe, with formation of local elements. Damage to cooling coils of transformer, to cooling pipes of counterflow condenser and to pipes of gas cooler due to deposition of products of corrosion on walls of tube by adhering air bubbles and formation of local galvanic elements between products of corrosion and metal of pipes.—*C.A.*

The Effect of Small Concentrations of Hexametaphosphate on Iron Oxide Surfaces. Fred Hazel. J. Phys. Chem. **46:** 516 (Apr. '42). To obtain any possible information on corrosion problems from colloidal standpoint, study undertaken of effect of sodium hexametaphosphate on colloidal iron sols. Stability, flocculation and deflocculation, and mobility detns. made with metaphosphate on iron oxide sols at different concns. and different hydrogen ion activities. Effect of Ca ion concns. on behavior also investigated. Parallel expts. conducted with sodium pyrophosphate and sodium orthophosphate. Some measurements also made on aluminum oxide suspensions. Using suspension of 0.2 g. of Fe_2O_3 at pH 4.6, 3.1 ppm. metaphosphate coagulated suspension and 4.3 ppm. dispersed it. In pure NaOH soln., iron oxide suspension shows isoelec. point at pH 8.6; ions such as Ca shift isoelec. point to higher pH, but in presence of 2.7 ppm. metaphosphate, isoelec. point at pH 5.6. Pyro- and orthophosphates less effective, requiring 4.5 ppm. pyrophosphate at pH 6.0 and 7.0 ppm. orthophosphate at pH 6.7. Amt. of metaphosphate required depends on pH, presence of other ions, especially multivalent ions such as Ca, and concn. of iron oxide. Less metaphosphate required at high pH than at low; amt. needed at pH 6.8 only 1.2 ppm. In presence of Ca, amt. needed increased; at pH 5.9, 2.4 ppm. metaphosphate required in absence of Ca, but 12.6 ppm. needed in presence of 66.6 ppm. $CaCl_2$. Ability of alkalies and metaphosphate to inhibit corrosion may be attributed to their converting iron oxide surface from electropos. to electroneg., thus rendering surface of metal more noble. May involve transformation of film of iron oxide, however thin, on metal surface from pos. to neg. state. Coagulation zone of metaphosphate extended from 1.2 ppm., with no $CaCl_2$ present, to over 1200 ppm. in presence of 222 ppm. $CaCl_2$. Effect on ortho- and pyrophosphates still greater, probably due to adsorption of Ca ion, thus decreasing neg. charge on particles and opposing recharging effect of phosphate ions. —*Selma Gottlieb.*

Rust-Proofing of Ferrous Metals. H. Silman. Sheet Metal Ind. **16:** 997, 1173, 1345, 1531 ('42). Various finishing and proofing methods reviewed critically and principles of selection for specific purposes considered. I. Following aspects considered under heading of electrodeposition: deposition, porosity, tarnishing, polishing and undercoating of nickel coatings; bronze plating, electro-tinning, composite tin coatings, corrosion of electro-tinned steel, electro-tinning of cast iron, electrodeposition of zinc and cadmium, individually and together, and discoloration of zinc plate; and corronizing process. II. Deals with acid pickling of ferrous metals; effect of annealing; hot-tinning of steel, cast iron and alloy steels; coating with tin-lead alloys, lead and zinc and relative properties of electrogalvanized and hot-dip galvanized coatings. III. Phosphate coatings of various kinds dealt with, as well as coloring processes. Brief ref. made to metal spraying. IV. Calorizing, chromizing, ihrigizing, cladding of various kinds and the use of paints, rubber and similar coatings considered. Testing of protective coatings referred to briefly. 38 refs.—*I.M.*

Corrosion of Pure Zinc Alloys by Fire-Extinguishing Liquids. R. Beythien. Korrosion u. Metall. (Ger.) **17:** 133 ('41). Action of various foam-type fire-extinguishing liquids and of carbon tetrachloride on 3 zinc-base die-casting alloys investigated and results discussed in detail. Anhyd. carbon tetrachloride has little action on alloys, but, in presence of water, severe corrosion due to acid formed by hydrolysis may occur. Action of foam-producing liquids depends on constituents, some prepns. being highly corrosive on some alloys. Recommended, therefore, that zinc-base alloys be used only for those parts which are not continuously wetted by liquid, i.e., those parts outside liquid container.—*I.M.*

Bacteria Found to Blame for Corrosion of Pipes. Anon. Sci. News Letter **42:** 217 (Oct. 3, '42). Bacteria found responsible for corrosion of iron pipes carrying deep well water in Miami Valley, Ohio. Usual chem. test revealed very little oxygen and practically no corrosive substances. Investigation led to discovery that organism chiefly responsible is coccobacillus of anaerobic type, which requires no oxygen for life processes. Other so-called "iron-consuming" organisms also found. By introducing oxygen into water found that rate of corrosion decreased as quant. of oxygen increased, being opposite of what would have occurred if oxygen had been cause. Although bacteria long known, connection with corrosion only recently suspected. Where water to be used for drinking, remedy is chlorination.—*P.H.E.A.*

Corrosion of Water Pipes in a Steel Mill. C. L. Clark & W. J. Nungester. Trans. Am. Soc. Metals *Preprint No. 26* ('42). Sulfate-reducing bacteria primary cause of severe corrosion in water-cooling pipelines and enclosed metal parts of well. Chem. anal. of corrosion products showed sulfides and free S. Lab. expts. reproduced FeS in few weeks. Chlorination should be ideal treatment for elimg. attack.—*C.A.*

Experiences With a Water Main Fabricated From Copper-Bearing Soft Ingot Steel. H. Grubitsch & J. Steiner. Gas u. Wasserfach (Ger.) **84:** 610 ('41); Chem. Zentr. (Ger.) **1:** 1035 ('42). Cu-bearing ingot steel (0.55% Cu) unsuited for mains and services for non-aggressive H_2O with carbonate hardness. Factory-applied bituminous coatings give protection if not mechanically damaged, but rust formation quickly occurs on repaired sections.—*C.A.*

Reconditioning Steel Gas Mains. R. B. Allen. Gas World **117:** 400 ('42). To prevent corrosion, Detroit Gas Co. developed method of coating steel mains *in situ*, before replacement necessary. Excavated main cleaned of scale by flame, deep pits arc welded and pipe finally wrapped and coated with bituminous pipe coating.—*C.A.*

Dependence of the Rate of Corrosion of Buried Iron on the Oxygen Supply of the Soil. H. Vine. Soil Sci. **54:** 159 ('42). Strips of Fe, attached to wooden handles, driven into soil at several sites in Trinidad, B.W.I., during rainy season. After 2, 4 or 6 wk. removed and cleaned and losses in wt. detd. Fact that loss in wt. decreased rapidly with increasing depth, especially during wettest periods, indicated that rate of corrosion dependent on O supply. Except at one site, where first and second 4" layers had pH values of 4.4 and 4.7, resp., losses in wt. independent of acidity and closely related to O supply as judged by soil texture and drainage. None of soils saline, calcareous or gypseous. Clean

Fe strips corroded more rapidly than those that had been in soil fortnight or more. Three portions of mixt. of sand and clay virtually free from org. matter adjusted to pH values 4.6, 5.3 and 6.3, resp., and pieces of Fe allowed to corrode in each. Pressure measurements and gas anals. during these tests showed that cathodic process of O absorption predominated when O supply plentiful, but that evolution of H also played part and might alone be responsible for corrosion in anaerobic conditions and that its rate increased with acidity. Mechanism of corrosion process discussed; 18 refs.—*C.A.*

Use of Soil Surface Potential in Locating Pipeline Corrosion. O. C. Mudd. Oil & Gas J. **41:** 1: 50 ('42). Potential differences observed at intervals on ground surface above buried pipeline predominantly caused by corrosion of pipe. Excludes areas where stray currents from outside sources prevalent. Anodic sections can be detd. within closer limits, and more detailed information on electrolysis can be detd. in given time.—*C.A.*

Flame-Priming Method of Preparing Steel Surfaces for Painting. E. W. Deck. Iron Age **150**: 17: 80; 18: 44 ('42). Flame-priming, while removing loose scale and dehydrating rust, does not remove scale that, because of tight bond, would serve as protection against corrosion. Shown that any scale that can resist stringent expanding action of sudden heating effect of high-temp., high-veloc. flames sufficiently tight to resist subsequent flaking. Consequently, increased protection against corrosion effected and causes of mill scale giving trouble under paint mitigated, while tightly bonded scale retained as added protection. When paint applied on warm surface, corrosion resistance increased. Removal of contaminants enables vehicle to reach steel surface where polar attraction forces can exert themselves to produce greatly increased bonding strength. Flame-priming and painting should proceed as continuous operation. Process being used to ever-increasing extent in structural-steel works, storage tanks, dams, pipelines, etc. 10 refs.—*C.A.*

Corrosion Protection of Storage Tanks. F. L. Newcomb, E. S. Dixon & C. F. Kelly. Proc. Am. Petrol. Inst. **28:** III ('42). Galv.-iron roofs showed life double that of plain steel for less than double cost. Galv.-iron tanks in small sizes showed merit. Aluminum roofs gave good service, but costly, particularly when aluminum rafters used. Various coatings, including aluminum and lead foil, paint enamels, synthetic resins, etc., generally unsatisfactory, although some protection given for short period. Outside rafters on small tanks reduced replacement costs. When corrosion due to aq. solns. of H_2S, spent caustic gave good results. Electrolytic corrosion of tank bottoms successfully controlled by cathodic protection. Most of foregoing protection methods, however, require unavailable critical materials. For many yr. concrete used as protection for various tank parts. Successful methods of applying reinforced gunite linings described and illustrated. These applied successfully when tank so corroded that replacement only alternative. Costs per sq.ft., totaling about half cost of new tank are: roof and structural members, 40¢; shell, 37½¢ and bottom, 35¢. Use of unreinforced gunite lining protection of floating-roof tanks described. Gunite protection of storage tanks appears most feasible means of preventing corrosion and maintg. tanks for duration.—*Ralph E. Noble.*

Electrolytic Protection of Water Systems. Paul S. Armstrong. Iron Steel Engr. **19**: 10: 34 ('42). Data given to show that electrolytic protection of water systems pos. and practical. Change in constituents depends on type of water, voltage and amperage used, temp. and kind and concn. of salts in soln. Boiler feed water received from system protected by cathodic system will still require further treatment, such as addn. of boiler compds. before admission to boilers, especially when carbon electrode used. With use of cathodic protection, possible that Fe and Mn can be removed at time protection to system applied.—*C.A.*

Principles of Corrosion and Cathodic Protection. N. Clark. Oil Wkly. **107:** 9: 21 ('42). Principles of electrolytic corrosion discussed with particular reference to corrosion of pipelines and its inhibition by cathodic protection. Pipeline corrosion largely caused by electrolytic action of stray currents picked up in areas near large sources of d-c. or by formation of galvanic cells between pipe and adherent rust or mill scale. Acid or salty ground water serves as electrolyte. Although corrosion rates of bare Fe and steel similar, when in contact with their corrosion products, rates

less in case of wrought or cast Fe. Corrosion processes may be inhibited by application of d-c. with copper oxide plate rectifiers, motor-driven generators, or motor-, engine-, or wind-driven generators. Rectifiers in general most economical. Bonding metals higher than Fe in electrochem. series to line satisfactory but expensive (65¢/kwhr. for Zn generating but 0.32 v.). Used to advantage only on local "hot spots" such as tank bottoms, where eff. compensates for high cost. Numerous electrolytic diagrams included.—*C.A.*

Tests on the Cathodic Method of Protecting Steel Water Tanks. GORDON C. O'BRIEN. W.W. & Sew. **87:** 285 (July '42). To det. cause and effect of cathodic protection of steel water tanks, expts. conducted at Baltimore, Md., since Oct. '40 and are continuing. Test tanks constructed of std. 10″ wrought-iron pipe, 3′ long, with blank flange welded on bottom. Water admitted to tanks at rate of 177 ml. per min. Current supplied from rectifier unit with range of 10 to 200 ma. and 6 to 60 v. Tank No. 1 arranged so that the 1″ diam. graphite electrode served as positive terminal (anode); tank No. 2 had electrode connections reversed; i.e., the ¼″ diam. stainless steel electrode served as negative terminal (cathode); tank No. 3 had no elec. connections and served as control. After few weeks, tank No. 1 with 9.5 v. and 40 ma. current applied had a protective coating of $CaCO_3$ on inside. Tank No. 2 badly corroded while tank No. 3 only slightly corroded. When running water into tank No. 1 stopped, $CaCO_3$ deposit disappeared from shell, pH dropped from 7.5 to 4.2 and alky. from 40 ppm. to 12 ppm. acid. Iron changed from 0.02 ppm. to 2.40 ppm. When flow resumed conditions as before restored. This indicated that hydrogen ion not protective agent, but rather alk. salts present in water (above pH 7.2) and deposited on shell. Atomic hydrogen film will protect iron by bringing galvanic voltage to zero (complete polarization), but such films practically impossible to attain. If voltage too low, film will not form; if too high, molecular hydrogen, which is itself corrosive, forms. This voltage will change with any change of electrolyte (compn. of water). To avoid these critical factors, voltage selected (above decompn. voltage of water) which will deposit on shell small quants. of dissolved salts, will not decrease pH nor increase iron content of water. From this study following conclusions drawn: (1) cathodic protection feasible and appears to be cheaper and more satisfactory than painting; (2) upper inside surface of tank above water level should be painted to protect against corrosive gases released by decompn. of water; (3) stainless steel electrodes with 30% chromium superior to graphite rods; (4) pH of water should be at least 7.4; (5) currents vary from 1 to 10 amp. at 5 to 30 v.; (6) after protective film on shell sufficiently thick, current adjusted to maintain just that thickness. Observations on utilization of cathodic method for cleaning old tanks and proper installation of cathodic equip. included.—*F. J. Maier.*

Experiments on the Effect of Cathodic Treatment on the Quality of Water. PAUL S. ARMSTRONG. J. Pa. W.W. Operators' Assn. **13:** 56 ('41). In Easton, Pa., 2 water tanks needed protection from corrosion. One not painted for 20 yr. other painted within 2 yr., but not satisfactory. Cathodic protection raised question of effect upon qual. of water with low alky. and pH, and red water trouble; hence some expts. before adopting treatment. 40-gal. hot-water tank with copper oxide rectifier and ½″ diam. stainless steel electrode used for first expt. Voluminous tables of anal. figs. and current data given. As conditions of expt. seemed to be different from those of actual practice, another tank constructed from stove-pipe iron, 12″ in diam., 67″ high, 64″ overflow and 8½″ surge line. Anals. on this run made and effects on tank noted. Areas free from rust in vertical strips down sides and around rivets. Since no gas noticed on side of tank or stainless steel electrode until iron rust removed, decided to use tank without any rust, but before leaks stopped, it rusted again. Lengthy discussion of reasons for cathodic protection follows. Author concludes that change in constituents depends upon type of water, amt. of voltage and amperage, temp. and kind and concn. of salts in soln.—*P.H.E.A.*

Corrosion Tests in a Water-Recirculating Air-Conditioning System. W. Z. FRIEND. Heatg., Piping & Air-Condg. **14:** 187 (Mar. '42). Corrosion tests of 18 ferrous and nonferrous metals and alloys made in large air-conditioning system. Tests made in wash water, in bottom of humidifier and in washed air stream beyond eliminators. Corrosion rates of all metals and alloys tested in dichromate-treated wash water extremely low, confirming treatment effectiveness. Local-

ized attack and pitting may occur on steel in crevices or under accumulated solids. Corrosive conditions particularly severe in air stream just beyond eliminators. Here nonferrous metals and alloys and stainless steels most resistant. Alloy steels superior to mild steel.—*Ralph E. Noble.*

Prevention of the Deposition of Carbonate Scale in Cooling Systems by Addition of Sodium Hexametaphosphate to the Cooling Water. H. Moll. Glückauf (Ger.) **76:** 684 ('40); Chem. Zbl. (Ger.) **1:** 1208 ('41). Addn. of 3 mg. sodium hexametaphosphate per l. to make-up cooling water with hardness of 3° (German) produced in cooling water, after repeated circulation, total content of phosphate of 1.5–1.0 mg. per l. and content of metaphosphate of 0.5–0.25 mg. per l. After operation for 1000 hr., scale dissolved from upper half of upper series of condenser tubes and fine, loose covering of tricalcium phosphate formed in lower half of tubes. To avoid corrosion caused by formation of local electrolytic elements, recommended that part of recirculating cooling water should be filtered to remove suspended matter which would settle on cooling surfaces.—*W.P.R.*

Copper Redistribution and Recovery

WPB Release No. 4032

A PROGRAM to redistribute idle copper water tubing now in the possession of water utilities having inventories in excess of practical working minimums, as defined in Utilities Order U–1, was announced August 11 by the War Production Board. It is expected that some $2\frac{1}{2}$ million pounds of the critically needed metal will be recovered for war uses.

Inventory records of water utilities operating in cities of 50,000 or more population are already on file with the Office of War Utilities. WPB is sending letters to those reporting excess inventories of copper tubing, informing them of the activities of the Copper Recovery Corp. in attempting to locate authorized war users for their materials in their present form.

If, however, existing stocks cannot be moved "as is" in a reasonable length of time, the Government is offering to pay the same prices as are effective in the rest of the copper recovery program. For material purchased for remelting or reprocessing, the Government will pay the following prices: tubing under $\frac{3}{4}$ in. in diameter, 24 cents a pound; tubing $\frac{3}{4}$ in. and over in diameter, 18 cents a pound; both prices f.o.b. point of shipment.

Water utilities in cities of under 50,000 population are believed to hold substantial amounts of the needed material. To bring these companies into the recovery program, the Office of War Utilities and the Redistribution Division have arranged to send them reporting forms.

The WPB is in a position to exercise its power of requisitioning in the case of water utilities which face legal obstacles to the sale of surplus material, or which, for any other reason, are unable or unwilling to sell their idle and excessive copper tubing to the Government for war use.